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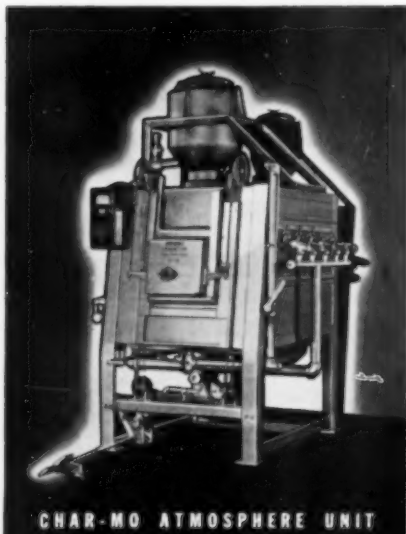


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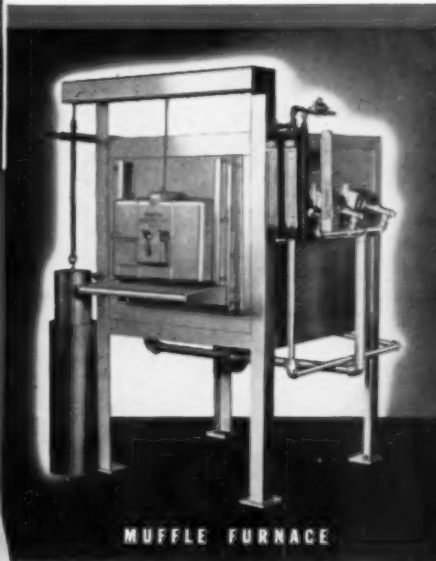
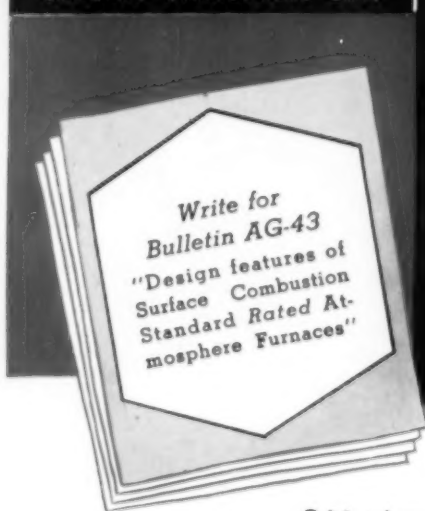
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Metal Progress

July, 1944

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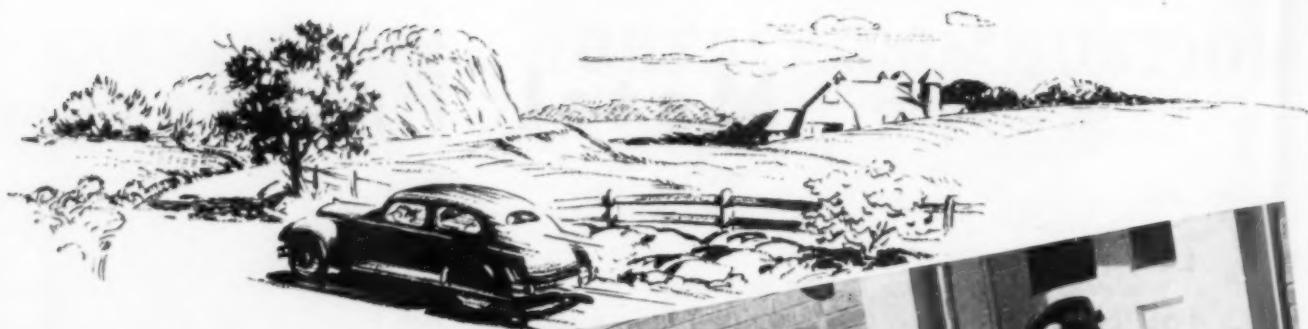
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Metal Progress

Volume 46

July to December, 1944

Weldability of Steel

Three interesting communications, printed below, comment on Martin Seyt's review of current opinion about "weldability", and its simple relationship to hardenability. The last contribution swings as far on the other side, with a systematic presentation of numerous other factors that influence the entire joint as a part of a serviceable structure

Deviations in Predicted Weldability by Lehigh and Rensselaer Systems

By Daniel Rosenthal

Department of Metallurgy
Massachusetts Institute of Technology
Cambridge, Mass.

IN *Metal Progress* for February, Martin Seyt outlines the work done at Lehigh and at Rensselaer, and finds that these two studies predict the same welding conditions for a joint of assumed geometry. While agreement will always be good, I wouldn't expect, in general, identical results when using the two systems.

Before going into details, it is well to point out that, whatever discrepancy there is between

the two systems, this discrepancy is due to a difference not in principles but in methods of measurement.

It will be recalled that both studies developed a relation between the rate of cooling near the weld and the welding conditions as defined by energy input, welding speed, and joint geometry. But whereas in the Rensselaer system the rate of cooling is measured directly by means of thermocouples, in the Lehigh system the rate of cooling is expressed by a position on the Jominy hardenability bar. This last procedure is entirely legitimate, since each distance from the end of the Jominy bar is known to correspond to a definite cooling rate, covering the range between water quench and air cool. However, the relation between distance from the end and critical cooling rate is far from being linear; in fact, the rate of cooling and the distance on the Jominy bar vary in a converse fashion. As a result, moderately high rates of cooling, for instance between 40 and 120° F. per sec., can be located with a reasonable degree of accuracy, whereas the exact location of such low rates of cooling as less than 20° F. per sec. is more difficult to estimate.

This difficulty does not exist when using thermocouples, since low rates of cooling can be measured even more accurately than higher rates of cooling.

Therefore, whatever discrepancy there is

between the two systems, low rates of cooling are likely to accentuate it. This means that greater discrepancy is to be expected with higher preheat, since the purpose of preheat is to lower the rate of cooling.

On the other hand, the Lehigh system oversimplifies the welding conditions by assuming that the two factors, geometry and preheating, are independent. Evidence to the contrary is given in the Appendix to the article published by the author in *Welding Research Supplement*, Vol. 23, February 1944, page 92-s.

On the basis of the foregoing general remarks, one may ask, "What is the maximum expected discrepancy between the two systems?" This is best answered by comparing the energy inputs tabulated by the two systems as a function of the rate of cooling — or, what amounts to the same thing, the corresponding distance on the Jominy bar. To make such a comparison possible at low rates of cooling, the data in the table at the bottom of this column are limited to $\frac{1}{2}$ -in. and $\frac{1}{4}$ -in. plates, welded with a 400° F. preheat. It is apparent from these extreme examples that the difference in the two systems may reach, exceptionally, a value of 20%.

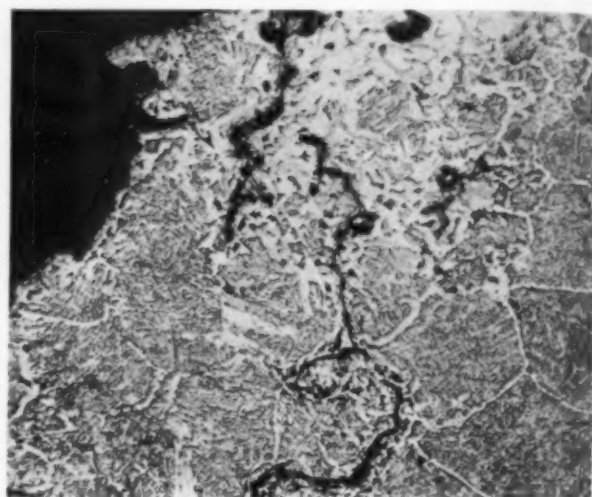
To conclude, it will be remembered that the present discussion has been limited to the problem of predicting rates of cooling from known welding conditions. The problem of predicting hardness and ductility, which after all is the main object of the two systems, is still dependent on how completely the mechanical properties of the metal adjacent to the weld are determined by the rate of cooling in the critical range of transformation of austenite. Experiments performed at Lehigh and at Rensselaer on a variety of carbon and low alloy steels seem to indicate that the prediction of mechanical properties can be carried out in a quite satisfactory manner for this category of steels on the basis of the rate of cooling alone. Whether the latter criterion is still sufficient when dealing with other steels can only be answered by a direct verification.

Table I — Comparison of Rensselaer and Lehigh Systems for a 400° F. Preheat

Speed of Welding: 6 in. per min.

COOLING RATE AT 1300° F. °F. PER SEC.	CORRESPONDING JOMINY DISTANCE IN $\frac{1}{16}$ IN.	ENERGY INPUT, KILOWATTS			
		$\frac{1}{2}$ -IN. PLATE		$\frac{1}{4}$ -IN. PLATE	
		RENS- SELAER	LEHIGH	RENS- SELAER	LEHIGH
40	7	3.78	3.6	1.62	1.8
35	7.8	4.0	4.3	1.74	2.15
20	10.5	5.05	6.0	2.37	3.0
10	15	7.5	8.5	3.75	4.25

Fig. 1 — Etched Section in Base Metal Near Weld That Developed "Hot Cracks". The defect follows the austenitic grain boundaries, and is ascribed by Mr. Boss to the segregation of a low melting eutectic, whose nature is as yet undetermined



Hot Cracks Versus Cold Cracks— to Distinguish Them in Welded Joints

By Gerard H. Boss

Metallurgist
Glenn L. Martin Co.
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MOST INVESTIGATORS of welding in the United States apparently assume that there exists only one kind of crack in welded base metal, that is the kind which occurs as a result of high hardenability of the steel. However, there exists another type of cracking whose cause and manner of occurrence have absolutely no relation to the gamma-to-alpha transformation. Since the two kinds of cracks are so fundamentally different in their cause and occurrence, it is important that welding and production engineers be able to distinguish between them so that the proper remedies may be applied.

The first and generally recognized kind of cracks is called "cold cracks" or "hard cracks". The susceptibility of a steel to cold cracks is very closely dependent on its hardenability and rate of cooling after welding. Since these cracks occur below 600° F. the cracked surfaces are always bright. Cold cracks are generally straight lines or smooth curves, which may or may not pass into the weld metal. They may run at any angle to the direction of the

weld. Cold cracks are more apt to occur in arc welding than in gas welding; this is because the oxy-acetylene flame puts more heat into the weldment than the arc does, thereby causing it to cool more slowly.

The second, and poorly understood type, is called "hot cracking" because of the temperature of its occurrence. It is directly related to some form of localized hot shortness. The fact that the cracked surfaces are always covered with a coating of the blue-black magnetic oxide of iron is in accord with the opinion of certain German metallurgists that the cracks occur above 1800° F. Hot cracks are usually crooked, but always run parallel to the weld. They occur in the base metal adjacent to the weld metal, but they never enter it. As can be seen in the photomicrograph these cracks follow the austenitic grain boundaries. Hot cracks are more apt to occur in gas weldments than in arc weldments.

It is believed that the hot shortness which results in hot cracks is caused by the segregation into the austenitic grain boundaries of a low melting point eutectic. Despite an extensive investigation at the Glenn L. Martin Co., the composition and nature of this eutectic was not discovered.

Weldability— a More Complete Definition

By Dr. Oss I. Temper

Comptroller
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WE WERE VERY MUCH interested in Martin Seyt's simplified definition of weldability of steel (*Metal Progress* for February, page 298) and his excellent summary of current ideas on the subject. However, weldability, it seems to us, is more complicated, and more difficult to define because of the involved interrelation of welding procedure and plate metal variables. It seems, at first thought, quite logical to restrict the evaluation of weldability to a consideration of the ability of a steel to endure a given welding procedure without setting up conditions which tend to produce failure of either the steel or welded joint during welding or in service. It might also appear desirable to assume that the severity of the welding procedure is purely a function of the severity of the imposed thermal cycle, as implied by the definition ascribed to Hodge and Gibson, and in Dr. Seyt's discussions of the Rensselaer and Lehigh experiments. If the principal criterion of weldability is absence of

base metal cracking during the welding operation, a quantitative solution of the problem either by direct determination of cooling rates or by relation of the weld cooling rates to maximum hardness produced in the plate should be possible.

However, there are strong indications that severity of the welding cycle cannot be judged by intensity of thermal cycle alone. Consider first the problem of "hard cracks", usually called "root" or "underbead" cracks (Fig. 2 and 3, page 71). Dr. Seyt states that such cracks do not form if the carbon content of the plate metal is limited to approximately 0.20% and the alloys kept low, or if the weld cooling rate is slowed down by preheating or using a large welding heat. Since these measures all tend to avoid the formation of martensite and to prevent hardness levels greater than approximately 350 Brinell, it might appear that the whole story of hard cracks is one of martensite transformation stresses.

The Problem of Underbead Cracks

Nevertheless, the above argument does not explain the following facts: Underbead cracks do not form if uncoated ferritic electrodes are used, or if either austenitic or ferritic electrodes having lime or titania base all-mineral type coatings are used, even though the base metal has relatively high carbon and alloy contents and the full martensitic hardness of Brinell 400 to 600 is developed in the heat affected zone. It appears that underbead cracking is definitely a characteristic of weld deposits made with commercial ferritic electrodes having coatings which contain substantial amounts of cellulose or organic materials. It might be argued that this cracking could be explained by differences in the weld metal stresses for deposits made by these various electrodes, but recent experiments by S. A. Herres at Watertown Arsenal and published in a paper entitled "Arc Welding Alloy Steels" in *Transactions*, for 1944, page 535, have shown that underbead cracks are prevented if commercial ferritic electrodes are heated at temperatures sufficiently high to drive off combined moisture and break up cellulosic compounds, and that the cracks reoccur if the electrodes which have once been heated are moistened before welding. This is shown in photographs of welds, kindly loaned by Lt. Herres. (Fig. 4, page 73.)

These and additional experiments (welding with uncoated ferritic electrodes in various atmospheres) may be most reasonably explained at present by assuming that underbead cracks are a flake-like defect associated with hydrogen, absorbed from the welding atmosphere by the molten weld metal; sufficient hydrogen diffuses

Table II—Weldability of Steel for a Given Welding Procedure (Metal Arc Process)
Influence of Base Metal Variables in the Production of a Serviceable Structure

Principal Base Metal Variables	Effect on Base Metal Zone Immediately Adjacent to Weld (Heat Affected Zone)			Effect on Weld Deposit and Fusion Zone (Interfused Base and Filler Metals)			Effect on Completed Weldment (Magnitude of Locked-Up Stresses)
	Susceptibility to Cracking During Welding		Properties of Metal in Absence of Cracks	Susceptibility to Welding Cracks	Soundness (Exclusive of Cracks)	Properties of Sound Weld Metal	
	Underbead Cracks (a)	Other Thermal Cracks					
Carbon content	Increase with carbon content	Increase with carbon content	Strength increases, impact resistance decreases with increase in carbon content	General increase with carbon content	Generally, no effect (d)	Strength increases, impact resistance decreases, with carbon pickup	Increase with carbon content
Hardenability	Increase with hardenability (b)	Increase with hardenability	Strength increases with hardenability. Impact resistance increases with hardenability until martensitic type microstructure forms, then decreases with hardness of final structure (c)	General increase with hardenability	Certain alloys may contribute to weld metal porosity (d)	Strength increases with alloy pickup from base metal (e)	Increase with hardenability
Prior heat treatment	Decrease by a heat treatment, which eliminates hydrogen present from prior processing, or which stabilizes carbides	Increase with yield strength and decrease with increasing ductility as established by prior heat treatment	Heat treatment which stabilizes carbides lowers effective hardenability during welding cycle	Increases with yield strength, decreases with increasing ductility, as established by prior treatment	No effect	No effect	Increase with yield strength, decrease with increasing ductility as established by prior treatment
Non-metallic content and distribution	Certain non-metallics (as sulphur) may react with and eliminate hydrogen dissolved in molten weld metal	Cracks may start at nonmetallics, especially if elongated by rolling or segregated at grain boundaries	Inclusions may decrease ductility and impact resistance, especially if elongated by rolling or segregated at grain boundaries; effect is very marked when heat-affected zone has high hardness	Some non-metallics may contribute to weld metal cracking	Certain non-metallics (as sulphur) may contribute to weld metal porosity or slag inclusions (d)	General decrease in strength and impact resistance with increased non-metallic content (d)	No effect
Porosity and surface defects	Decrease with increased porosity which permits escape of hydrogen diffused into base metal	Cracks may originate at porosity or surface irregularities	Strength and impact resistance decrease with increase in porosity or surface irregularities, depending largely upon location	No effect known	Surface oxides may contribute to weld metal porosity and slag inclusions	No effect known	Surface irregularities give rise to stress concentrations

NOTES: (a) Underbead cracks are not formed if electrode coating is low in hydrogen compounds.
(b) Effect of certain alloys on solubility and diffusibility of hydrogen may have undetermined influence. Carbide stabilizing alloys may decrease effective hardenability during welding cycle.

(c) In absence of cracks, best combination of strength and impact resistance is obtained when martensitic type microstructure is formed in heat affected zone by first passes and is tempered to a hardness approaching that of the base metal by subsequent weld passes or postheat treatment.

(d) Depends, to a large extent, upon specific gas and fluxing reactions during welding.
(e) Impact resistance increases with alloy pickup from base metal, for usual low carbon ferritic weld metals.

into the base metal to crack the hardened areas during or shortly after the welding cycle. Even though the mechanism be due to hydrogen occlusion rather than martensite transformation stresses, hardness might still be used as a measure of cracking susceptibility, if welds made with the usual type of electrodes were free of cracks when the highest hardness was less than a certain Brinell number. Unfortunately, this is not strictly true.

Underbead cracks have frequently been observed when the hardest part of the heat affected zone was less than 300 Brinell. On the other hand, hardnesses of 500 to 600 have been observed with no indication of cracking. It would appear that the underbead cracking phenomenon is dependent upon a rather critical balance between the amount of hydrogen diffused into the base metal and the ductility of the metal at the time of cracking. Neither of these is truly reflected by hardness measurements, and therefore the best means of determining cracking susceptibility appears to be inspection for cracks on sections of welds made in the same conditions as will be used in fabrication.

Underbead cracks are not the only type of base metal cracks that may develop. It is easily demonstrated that *any* steel may be made to crack by heating and then restraining it so that the steel literally pulls itself apart by contractional stresses or cooling. Any foundryman or heat treater who deals with large or complicated sections has seen many such cracks. Thus, "toe" cracks in a single bead weld deposit, or transverse cracks in a welded joint, are apparently related to the strength of unaffected base metal, to its hot shortness, or a poor distribution of non-metallics in the heat affected zone, as well as to variables in the design and welding procedure.

Ductility of the base metal affected by the heat of welding deserves some discussion, though possibly it is of no great importance in ordinary weldments, provided cracks are prevented during the welding operation. In the first place, I wish to emphasize that martensite of relatively low carbon content (0.30% carbon or less) is by no

means inherently brittle. The following properties are not unusual for 0.27% carbon rolled plate material (of sound steel quality, and with sufficient alloy to harden fully in 2-in. section). Figures are for pieces water quenched from 1600° F.

Tensile strength	250,000
Yield strength	225,000
Reduction of area	40%
V-notched Charpy	20 to 35
Brinell hardness	480

Strength and hardness of such material

decrease by tempering, by heat of subsequent welding passes, or by postheat treatment. At the same time ductility and notched-bar impact energy increase. It is well established that, in the range of 200 to 400 Brinell, a fully hardened and tempered steel has considerably higher resistance to impact, particularly at sub-zero testing temperatures, than steel of equivalent hardness which was initially slowly cooled from the austenitizing temperature.

For weldments designed to resist shock, repeated high load, or low temperature service, and which are preferably made from heat treated steel, it would appear from the above considerations that, in the absence of cracks, the presence of martensite in the heat affected zone is not entirely deleterious. On the other hand, a slowly cooled pearlitic heat affected zone may actually lead to brittle failure through this zone under severe shock loading.

It follows that, for ordinary weldments made from as-rolled or normalized steel and designed

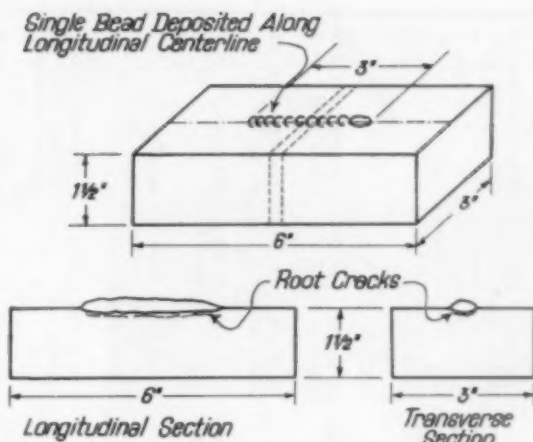


Fig. 2 — Test Piece for Weld Bead Hardness; Dotted Lines on Perspective Sketch Represent Slice for Crack Inspection

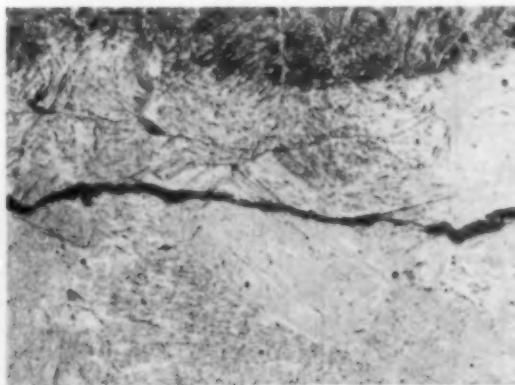
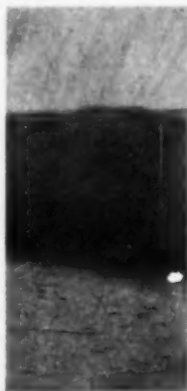


Fig. 3 — Root Crack Under a Single Weld Bead on 0.40% C Alloy Steel Plate (Longitudinal and Transverse, $\times 4$ and $\times 100$)

Table III—Suitability of Welding Procedure (Metal Arc Process) for a Given Base Metal
Influence of Welding Procedure Variables in the Production of a Serviceable Structure

PRINCIPAL WELDING PROCEDURE VARIABLES	EFFECT ON BASE METAL ZONE IMMEDIATELY ADJACENT TO WELD (HEAT AFFECTED ZONE)				EFFECT ON WELD DEPOSIT AND FUSION ZONE (INTERFUSED BASE AND FILLER METALS)			EFFECT ON COM- PLETED WELDMENT (MAGNITUDE OF LOCKED-UP STRESSES)
	SUSCEPTIBILITY TO CRACKING DURING WELDING		PROPERTIES OF METAL IN ABSENCE OF CRACKS	SUSCEPTIBILITY TO WELDING CRACKS	SOUNDNESS (EXCLUSIVE OF CRACKS)	PROPERTIES OF SOUND WELD METAL		
	UNDERBEAD CRACKS (a)	OTHER THERMAL CRACKS						
Weld Heat Input Increases with: 1. Current and voltage; 2. Exothermic reactions in arc Decreases with increasing arc travel speed, endothermic reactions, and radiation from arc	Decrease with heat input sufficient to prevent formation of martensitic type microstructure	Increase with heat input, except when it is sufficient for low thermal gradients or low cooling rates	High heat input deepens heat affected zone, increases amount of coarse grained, high temperature structure, with considerable variation of strength and impact resistance of this structure in alloy steels	Decreases with increased heat input	General improvement with higher heat inputs except when followed by slow cooling which may produce porosity	No definitely established relationship between weld heat input and properties of sound weld metal	Locked-up stresses increase with heat input	
Weld Cooling Rate Increases with : 1. Mass of metal adjoining bead; 2. Thermal capacity of surroundings; 3. Conductivity of weld metal Decreases with increasing pre-heat temperature, interpass temperatures, and insulation of slag deposit	Increase with cooling rate sufficient to form martensitic type microstructure	Increase with cooling rate	Strength increases with cooling rate; impact resistance increases with cooling rate until martensitic type microstructure forms, then decreases with increasing hardness of final structure	Increases with cooling rate	Soundness improved by slower cooling rate, except when preceded by high heat input. See above	Strength increases with cooling rate; impact resistance increases with cooling rate for usual low carbon, ferritic weld metals	Locked-up stresses increase with cooling rate	
Composition of Molten Filler Metal (b)								
Carbon content	Carbon has no known effect	Increase with carbon content (d)	Carbon has no effect	Increases with carbon content	Effect of carbon varies (f)	Strength increases; impact value decreases with carbon	Increase with carbon content	
Alloy content	No effect of alloys known (c)	Increase with alloy content (d)	Alloy content has no effect	Variable, depending on alloy	Effect of alloys varies (f)	Strength and impact generally increase with alloy	Increase with alloy content	
Non-metallic content	Certain non-metallics may eliminate dissolved hydrogen	Non-metallic content has no effect known	Non-metallic content has no effect	Certain non-metallics may possibly contribute	Certain non-metallics increase porosity	General decrease with non-metallic content	No effect	
Gas content	Increase with amount of hydrogen in solution	No effect definitely established	Hydrogen causes general embrittlement. Effect decreases on aging	Hydrogen probably contributes	Effect varies (f)	Hydrogen embrittles; effect decreases on aging	No effect	
Restraint on Weld Joint Increases with the rigidity of the structure; decreases by variation in sequence of joints welded, or deposition in joint	Growth of cracks, once formed, facilitated by increase of restraint	Increase with degree of restraint	Effect not definitely established	Increases with degree of restraint	No effect	Effect not definitely established	Locked-up stresses increase with degree of restraint	
Reheating After Initial Deposition By subsequent weld deposits	Decrease when interpass temperature prevents martensitic microstructure	Decrease with sequences producing low thermal gradients or cooling rates	Strength decreases; impact resistance increases with increased interpass temperature (e)	Decreases with sequences producing low thermal gradients or cooling rates	No effect	Strength decreases (e)	Decrease with sequences producing low thermal gradients or cooling rates	
By postheat treatment (subcritical stress relief anneal)	Does not prevent their growth	Does not prevent formation but limits their growth	Strength decreases; impact resistance increased with tempering time and temperature (e)	Does not prevent, but limits growth	No effect	Strength decreases (e)	Decrease with higher temperature, and slower cooling	

NOTES: (a) Underbead cracks are not formed if electrode coating is low in hydrogen compounds.
 (b) Controlled by core wire and coating compositions and atmospheric conditions.
 (c) Effect of certain alloys on solubility and diffusibility of hydrogen have undetermined influence.
 (d) Carbon and alloy contents of weld metal are not serious factors in thermal crack formation in heat-affected zone of low carbon, low alloy base metals.
 (e) Impact resistance increases with increased interpass temperature, or with increases in annealing time and temperature, except for precipitation hardening alloys in which case the opposite effect may be obtained.
 (f) deleterious effects may be obtained if austenitic type weld or base metals are reheated.
 (g) Effects of carbon, alloy content, and gas content which may tend to produce unsound weld metal are influenced by specific gas and fluxing reactions during welding; controlled to a large extent by electrode coating composition.

for service well within the elastic limit of the structure, a requirement for a certain ductility in a test weld is valueless except as a means of disclosing base metal cracks. In the absence of such cracks, plate metal defects, or severe notches, failure of these weldments, in my experience, always originates in the weaker weld or unaffected base metal rather than in the heat affected zone.

A complete weldability definition probably should take into account all influences of base metal variables on production of a serviceable welded structure. In addition to the conditions in the heat affected zone which have already been discussed, the influence of the base metal variables on soundness, strength and cracking susceptibility of weld metal, and on the magnitude of undesirable locked-up stresses in the structure may be important. (For a discussion of the importance of locked-up stresses in welded structures, see J. Tutin, "Locked-Up Stresses", in *Steel* for February 17, 1944, page 136.)

Table II on page 70 illustrates the influence of the principal base metal variables on the conditions which may cause a steel to be classed as unweldable, while Table III, opposite, illustrates the influence of the principal welding procedure variables on these same conditions. Present knowledge does not permit adequate treatment of all these variables, but I believe that such tables are useful as a method of separating out the factors and studying them individually so that, in time, it may be possible to revise and complete them.

The problem of the welding engineer is to determine the most economical and practical compromise between weldability of base metal and suitability of welding procedure which will satisfy the requirements of a specified structural design. To do this he must devise inspection methods and control tests which will assure him that the base metal finally selected has sufficient weldability under the exact conditions of welding which will be used in fabrication. In this con-

Fig. 4 — Macro-Etched Transverse Sections Through Single Weld Beads Deposited on Normalized 6150 Steel

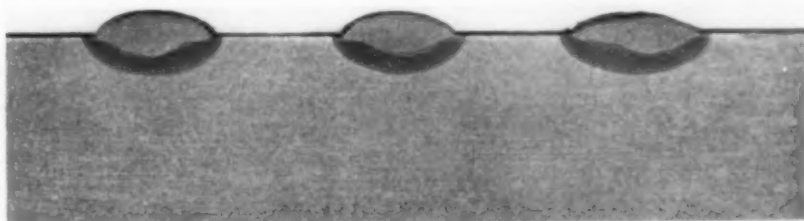
Deposited With Untreated Electrode	Deposited With Dried Electrode	Deposited With Electrode First Dried, Then Wet
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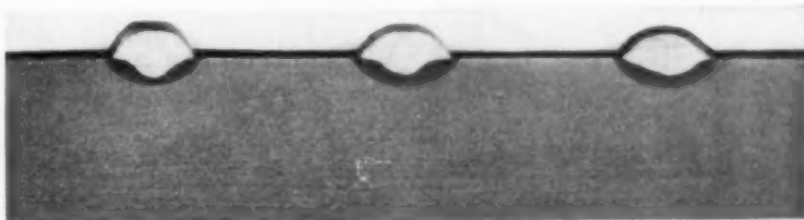
Welded with $\frac{1}{8}$ -in. commercial ferritic electrode, A.W.S. Grade E7010



Welded with $\frac{1}{8}$ -in. commercial ferritic electrode, A.W.S. Grade E7020

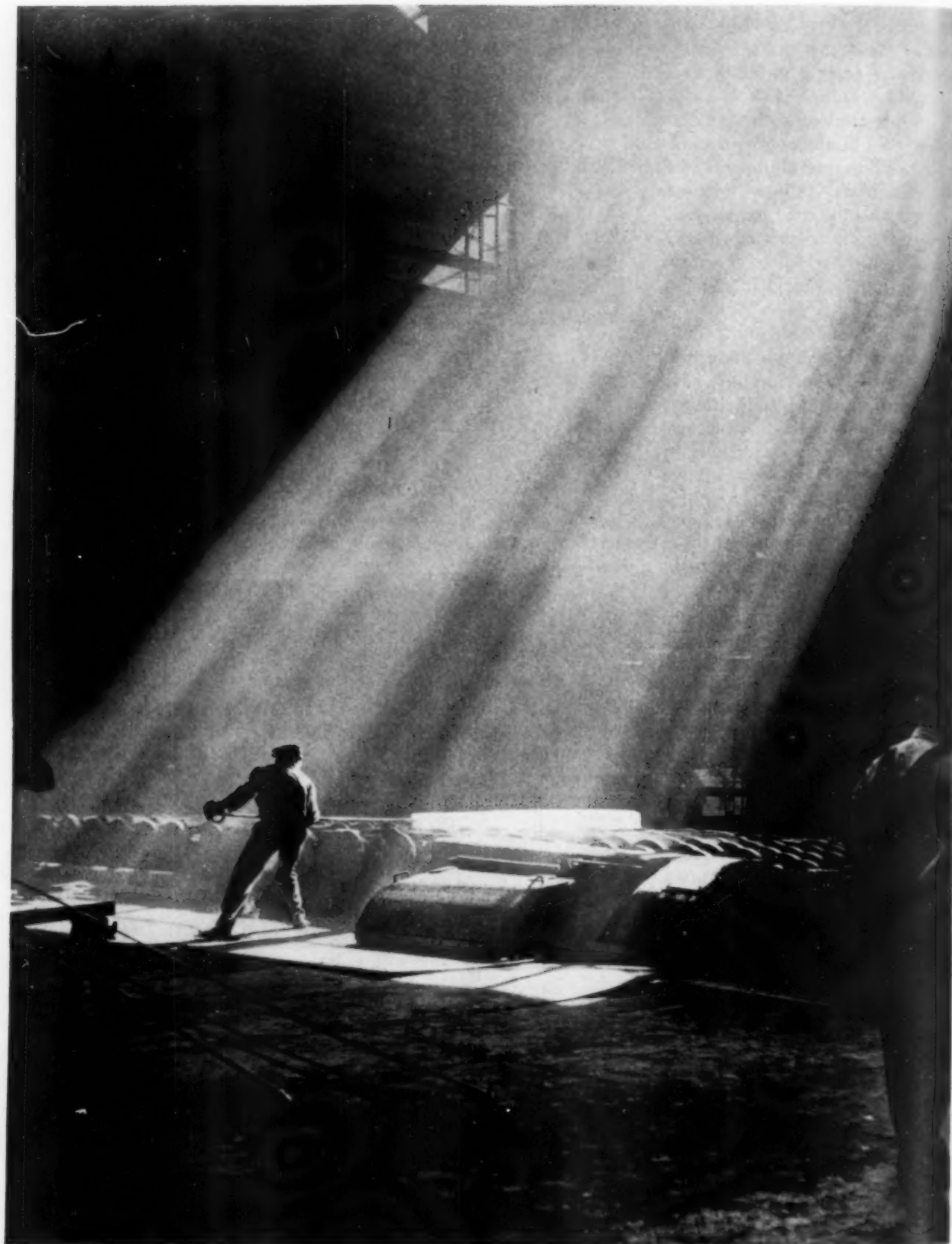


Welded with $\frac{1}{8}$ -in. ferritic electrode with stainless type coating



Welded with $\frac{1}{8}$ -in. austenitic electrode

nection the usual methods of relating weldability either to maximum hardness in the heat affected zone or to ductility in a bend test (unless used as a preliminary, or actually correlated with service performance by a background of experience for a given welding application and base metal analysis) are not as illuminating as a system of crack inspection by macroetching or magnafluxing sections of typical or duplicate joints of the particular weldment. In some instances weldability may be evaluated by testing to destruction actual or simulated weldments or sections of weldments. For many applications, final and complete evaluation must await an analysis of service experience.



Plates, Plates, More Plates!

Approach tables to 140-in. mill. This — and others like it — sent 13 million tons of steel plate to our shipyards in 1943

Metal Progress; Page 74

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Yesterday, Today and Tomorrow

By R. E. Zimmerman,
Vice President,
United States Steel Corp. of Delaware,
Pittsburgh, Pa.

In this address, delivered in May before the Annual Meeting of the American Steel Warehouse Asso. in Chicago, is contained a conservative appraisal of the future uses of steel products as affected by the research and technical developments of the recent war years. Purchase of steels by properties in fabrication and use, rather than by chemical analysis, is listed as a future trend. General improvement in uniformity, surface and gage is predicted through better steel making processes; wider use of low alloy and "intensified" (boron) steels is certain; better heat treating and welding techniques will make better products for civilian customers. Dr. Zimmerman also believes much light gage steel will go into small buildings and residences.

MOST OF YOU KNOW, statistically, what is happening to the steel industry these days. You know, for example, that in 1939 when Germany invaded Poland, the annual ingot capacity in this country was approximately 82,000,000 tons, and that there was plenty of steel for civilian uses. The ingot capacity is now in excess of 94,000,000 tons, and civilian consumption is highly restricted. In 1939, in the days of plenty, the production of ingots was 52,500,000 tons; last year it was 88,800,000. Against that let us set the ten year average peacetime figure, 37,400,000 tons, and the comparison is impressive.

The purpose of citing these figures is not to benumb you with statistics but rather to suggest something of the atmosphere in which the steel fraternity will be working when the war

ends. Certainly there will be an abundance of steel products for unrestricted sale, and unless the law of supply and demand is repealed, plenty of competition.

Steel has not been alone in the enormous expansion of productive capacity, nor in the matter of persistent research and development. Vast quantities of aluminum, magnesium, metal powders, castings, plastics and plywood will be seeking peacetime markets as never before. They will be supported by an impressive fund of knowledge and determination, not hesitant about reaching into fields heretofore served mainly by steel products, wherever and whenever there seems to be a chance that substitutes can meet the requirements, technically and economically. No doubt there will be overlapping areas in which competition will be quite pronounced.

The history of most products has been that they have found logical and proper applications in which to serve the needs of mankind. With such diversified requirements as our present complex civilization has to fill, we welcome each new substance in turn, believing that it has something to contribute to progress. It usually has. We observe with interest, however, that the metal which held sway in the remote years of the Bronze Age has not yet passed into oblivion, and that there are more candles made and sold now than in the days when man depended mainly upon them to light the darkness.

From time to time many fancy tales, based upon too little data, are to be read about this or that material and what it will do to render most of the others obsolete. Steel itself is sometimes an offender in this regard. Unfortunately, all such statements are not submitted promptly to widespread technical and economic analysis. Calm appraisals might readily show wherein certain claims are exaggerated. Competitive mate-

rials, too, have their shortcomings and handicaps as well as their good properties. Some of them, such as plywood and the plastics, are organic, and certainly cannot serve at high temperatures. On account of their low strength and high cost, the plastics can hardly be considered formidable contenders in structural applications. Some of the metals are none too resistant to the effects of heat, even below the red range. Again, while the light metals admittedly are light, they sag much more than steel under load, because of their low modulus of elasticity. Hence in the design of structures, full advantage of their relatively low density cannot always be realized.

Workability, strength, weldability, resistance to wear, relative cost, and many other factors raise questions which must be answered in individual cases before a material can be approved for widespread purposes. So, while inter-product competition lies ahead and is not to be dismissed as inconsequential, steel is by nature well equipped to make a case for itself, if its sponsors do not become afflicted with an unwarranted feeling of timidity.

Performance Rather Than Analysis

While laying before you these considerations, likely to be found in the future, we should like to mention a trend which may readily increase in emphasis. It is the tendency to buy and sell properties and performance rather than just so much carbon, phosphorus, sulphur, and metallic alloying elements in steel. A customer usually knows what services he would like to have a steel perform; he may or may not know how to translate his desires into terms of chemical composition. He wishes a grade of steel to do the job at hand. The controlling requirement may be a specified depth or range of hardenability, or ready weldability with moderate accompanying strength, or particularly good machinability "with as much toughness as possible". In any one of these cases there might be several compositions which would do equally well; one might be readily available and the other subject to extended delivery. By arranging purchases on the basis of requirements to be met in service rather than upon the arbitrary specification of one chemical composition, the customer might often do himself an extraordinarily good turn, at no inconvenience to his supplier.

The remaining discussion may be devoted, advantageously, to considering the future effect of wartime research and development.

In the first place, we should recall that when the national emergency came upon us, research

was already organized, entrenched, and functioning in the steel industry. The development of basic material for armament and munitions did not have to "start from scratch". A vast fund of metallurgical and engineering knowledge had been accumulated, and experience in producing steel to the exacting requirements of the great and diversified manufacturing industries of this country was extensive. Truly enough, in facing the mounting needs of the armed services, emphasis had to be shifted quickly to accommodate the specific demands for grades of steel with special combinations of properties, but the high level of existent knowledge served as an excellent starting point. The general know-how in research was on hand, awaiting application.

As is usual, the pace of research and development was greatly accelerated by the advent of war. Normally-moving projects became urgent; different parts of the field were explored; the tempo of all necessary investigations was quickened; speed became a more important ingredient in all programs of research. As a result of the acceleration you will find, at the cessation of hostilities, a large dividend of additional knowledge added to the yield of appropriate normal developments for the period in question. That is sort of a promise; I shall try to indicate what it comprehends.

Among the matters which appear as certainties, mention may be made first and appropriately of the general improvement of quality resulting from advancements in the steel making processes. Continued study of the physical chemistry of steel making, contributing to better regulation of metallurgical reactions, slag composition, temperature, and degree of deoxidation, has led to greater refinement in practice and better control of product. Now, unfortunately for purposes of exposition, there is nothing glamorous about singing the praises of improved carbon steel plates, shapes, bars, and similar products, or in extolling the virtues of the improved processes and equipment back of them. The mere mention of one decidedly new but relatively unimportant steel product would outweigh, in popular interest, a full account of the immense amount of effective engineering and metallurgical work expended in enhancing the useful characteristics of the more common products. Yet there are few factors which surpass in importance the one just proclaimed.

A second matter, which likewise has most favorable implications, stems from the large wartime expansion of the steel industry. The great increase in capacity during the past several years has brought with it some of the finest and most

improved equipment — mechanical, thermal, and electrical — ever devised. You will readily appreciate what this can mean with respect to maintenance of contour and gage, uniformity of quality, and surface finish.

The third item for mention here promises something in the way of products, but at the moment carries a few shearing fins. Wartime research has greatly intensified the study of the role of the alloying elements in steel, making for their more rational use in setting up desired combinations of properties. The trend away from an excessive number of grades of alloy steel was well under way before the war, and interested technical groups were working upon a simplification of the unwieldy list of specifications. In the emergency, recourse had to be taken to progressively smaller lists of permissible grades, until finally the matter became critical, and the number was reduced, by official directive, to a minimum. A special aspect was the development of the National Emergency steels to meet the crisis caused by the too rapid exhaustion of our available supply of such metals as chromium, vanadium, nickel, and molybdenum. The NE steels, so called, were designed to make the most effective use of the strategic materials on hand, utilizing the alloy content of carefully segregated scrap insofar as possible. Metallurgically they relied in most instances upon the cumulative effect of relatively smaller amounts of multiple alloying elements, rather than upon that of larger percentages of one or two.

The principal members of this series of new, particularly the triple alloy (chromium-nickel-molybdenum) types, have been performing valiant service. They have helped solve a difficult situation, have saved large quantities of alloying elements, and may be important factors in the simplified list of standard grades available after the war. Economics and metallurgy will chase each other around the stump before a clear decision on this point is reached in times of normal commercial enterprise. Moreover the size and condition of the alloy steel scrap pile will have an influence upon the future of the National Emergency Steels when the word "Emergency" is dropped from the name.

Another interesting development, the fourth in line for review, is that of the so-called "intensified steels". They are designated as such because there is added to the molten steel, after it has been deoxidized, one or another of a group of rather unusual metallurgical agents, which seem to intensify certain effects of the more common alloying elements. "Certain effects" means particularly, or almost exclusively, hardenability.

There is quite a variety of these addition agents, but they all contain boron in some form, hence in some quarters the treated products are referred to as "boron steels". The intensifying effect is quite pronounced, it does afford a means of conserving metallic alloying elements, and the steels are being applied in substantial tonnages to war requirements which have peacetime equivalents. It should be stated that the work on this development was started some years before 1940, but that it received its principal impetus and came into fruition more recently. Further research work is in progress, on an extensive scale, and metallurgists look for a considerable increase in the use of the intensified steels, not only during the remainder of the emergency, but also in the ensuing years.

Advances in Heat Treatment

Now as a fifth item, but not fifth in order of importance, something must be said of the immense amount of work which has been done on the heat treatment of steel during this period of inordinate activity. From armor plate to bayonets, or from helmets to cartridge cases, as you choose, the field has been explored with painstaking care by producers and fabricators of steel. The best of existent technological data has been fortified by additional intensive studies. Precise procedures and properly regulated cycles, based upon detailed metallurgical investigations of the steel to be treated, have been devised and specified. They have been implemented with adequate equipment, controlled by excellent instruments, and followed by heat treaters enthusiastically because of the superior results achieved. Excessive cracking, distortion, and lack of uniformity had to be overcome to meet production schedules — and were overcome. This advancement in the science and practice of heat treatment, fostered as a necessary part of the war effort, will be a boon to the steel business in the succeeding era.

Matching in importance the developments in heat treating, I mention as item number six the forward sweep of welding as a tool of fabrication. Without the modern techniques and practices of welding, the amazing performance of American industry in meeting the requirements of the armed services, with admirable speed, would have been impossible. Grades of steel which a few years ago were not considered commercially weldable are now welded satisfactorily, as a result of concerted study and effort. Because of the widespread use of welding in its various forms for so many purposes, "weldability" as a

characteristic of any steel offered for sale is becoming a primary consideration. Good weldability in any grade goes back through the various processes of production and is one of the objectives of the producer. Purchases will be made on an increasing scale with weldability as a requirement, and in due time may be mentioning air-hardening, residual stresses, checking, and the effect of thickness. Thus you will find that the present emergency has pushed the clock ahead.

In the case of the next or seventh item, however, the clock stopped. It stopped because of the necessity of devoting attention, in unreserved measure, to wartime steels and to the conservation of alloying elements. Reference is to the low alloy steels of high strength and high resistance to corrosion. They were developed and well on their way in 1941, doing service mainly in mobile equipment such as railroad cars, trucks, power shovels and even ships. The principal merit of these steels was that they lent themselves to designs and constructions by which a substantial percentage of dead weight was eliminated, by virtue of the coincident features — marked corrosion resistance and enhanced tensile properties. The war effort merely postponed but did not eradicate this development. In many fields the economies to be realized from reductions in weight are too important to remain dormant indefinitely; hence the idea is growing into a potentially widespread post-war demand.

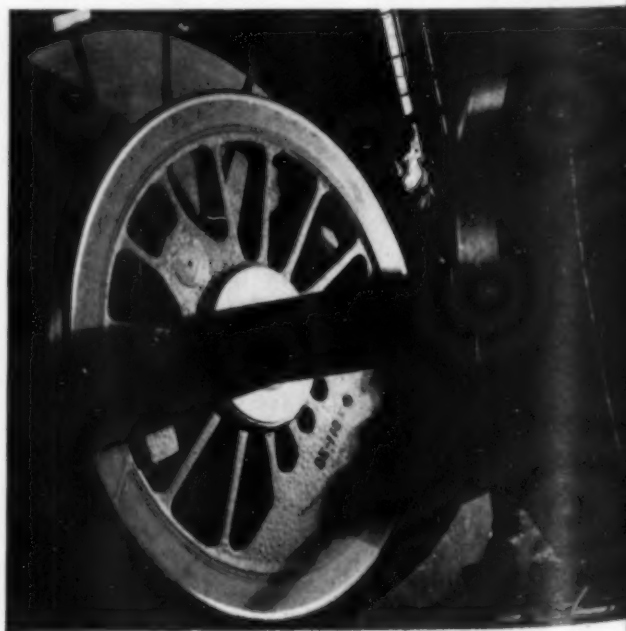
Continued research throughout recent years has contributed much to the development of steel products electrolytically coated with tin, zinc, and other metals. They will be available for commercial uses after the war. In quite a different category we find some of the highly alloyed steels, further developed for particular needs of the armed services, which will likely be applied to special purposes in the future. One such is the material now used for gas turbine blading, often called "super-charger steel", which is well adapted to operate at the high temperatures encountered in the exhaust systems of airplanes. Then there are the well known members of the stainless steel family, improved and better than ever, which will be ready to shift from the service canteen or mess hall to the home and hotel and restaurant, when the signal is given. Essential processing industries have been demonstrating the merits of the chromium-nickel-molybdenum stainless grades for many purposes, and have enjoyed the versatile corrosion resistance of the more complex alloy.

All of you know that the armed forces

have extended the use of steel in huts, task force buildings and many small structures. This experience has been quite in harmony with the idea of incorporating steel, much more extensively, into the construction of residences and commercial buildings. One bit of research which has an important bearing upon this wider use of steel is the systematic study, now yielding practical results, of the engineering characteristics of cold formed, light weight structural members for just such purposes. Before long the steel industry will offer the newly acquired data to designers so that they may take full advantage of it in planning their structures. The broad aspect of this line of engineering research is that it will aid in the rational utilization of steel — and thus benefit all parties concerned.

Now all that has been said in this attempt to tell you something of what has been happening to the technology of steel during the war is indicative rather than comprehensive. We are not in position to close with the familiar words of one of the radio news commentators, to wit, "and up to the minute that is all of the news". To go into such matters as the influence of compressive stress on the fatigue endurance of steel, or the latest procedure for crackless hardening, or the details of the improved bessemer steels, would be an undue encroachment upon your time. It is appropriate to say, however, that during the past four years the accelerated development of knowledge in regard to the production, treatment, selection and utilization of steel has been most gratifying and should lead to many new opportunities.

Photo by Rittase



"Available" Beryllium in Copper

By H. G. Williams

Chief Metallurgist
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Beryllium-copper having the required analysis may fail to develop expected properties. Beryllium present but not "available" for hardening is often responsible for this trouble, as well as for certain difficulties encountered in fabrication

BERYLLIUM-COPPER, as is well known, is hardened by the precipitation of beryllium from its solid solution in copper (the alpha phase). The precipitate is known as the gamma phase. Obviously, therefore, precipitation hardening can only be brought about by the beryllium that is present in the alpha phase after the so-called solution treatment. Beryllium in any other form in the alloy than the solid solution is therefore not "available" for hardening.

The term "available" beryllium in the title of this brief article means that beryllium which is in solution in the alpha phase. This available beryllium is what the spring manufacturer has to work with and determines the final spring properties.

Present specifications for beryllium copper (American Society for Testing Materials, B-120) call for the following analysis:

Beryllium	1.90 to 2.20%
Additive elements to control grain size (nickel or cobalt)	0.50% max.
Other impurities	0.50% max.
Copper	balance

Few suppliers furnish metal with over 2.0% beryllium due to the difficulties of casting and rolling higher alloys. So here is the first limitation to the maximum possible amount of available beryllium. Next, the additive elements such as nickel or cobalt tend to combine with beryllium to form beryllites, as shown in Fig. 1, which lock up a certain amount of the element and so have the effect of reducing the amount of beryllium that remains for solution in the alpha phase; these added elements therefore tend to reduce the amount of available beryllium. Finally, the specification allows 0.5% other impurities which may include silicon, iron, aluminum, tin, chromium or phosphorus. Some of these impurities may form compounds with beryllium as well as affect the solubility of beryllium in copper, further reducing the available beryllium for hardening. All of these factors are to some degree predictable if a complete chemical analysis is obtained for the material, and reliance is not placed upon a beryllium content alone.

However, the factors having the largest effect on the available beryllium are due to mill and foundry practice and are not revealed by chemical analysis. Theoretically about 2% beryllium may be dissolved in copper and retained there by proper casting and mill procedure. If, however, large castings are made and slowly cooled, considerable amount of beta phase will form. This second phase contains from 4 to 10% beryllium, and even a small amount of it removes much beryllium from the alpha solution. This beta phase, when poorly distributed or found in clumps or stringers (shown in cross section in Fig. 3) may have several undesirable character-

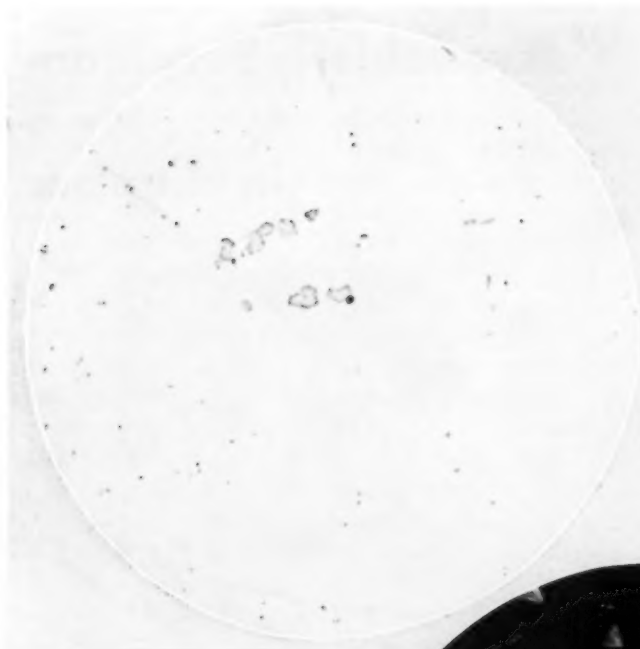


Fig. 1 (Left, Above) — Specimen of Beryllium-Copper, Unetched, at 500 Diameters, Showing Beryllite Particles

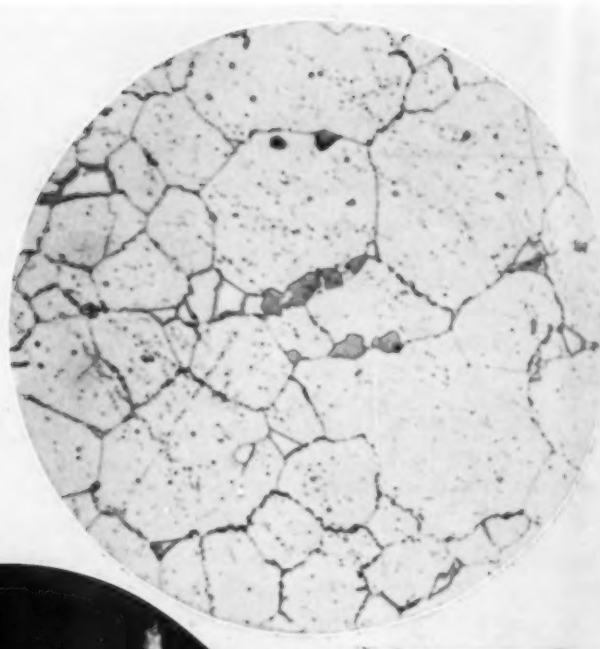


Fig. 2 (Right, Above) — Same Specimen as Fig. 1, Etched to Bring Out Both Beryllite and Beta Phase, the Latter Being Lighter in Color With Gray Borders. Both constituents deplete alpha phase of beryllium. Cross section of specimen, not heat treated. (Micrographs courtesy of L. MacNaughton, Materials Laboratory, Sperry Gyroscope Co.)

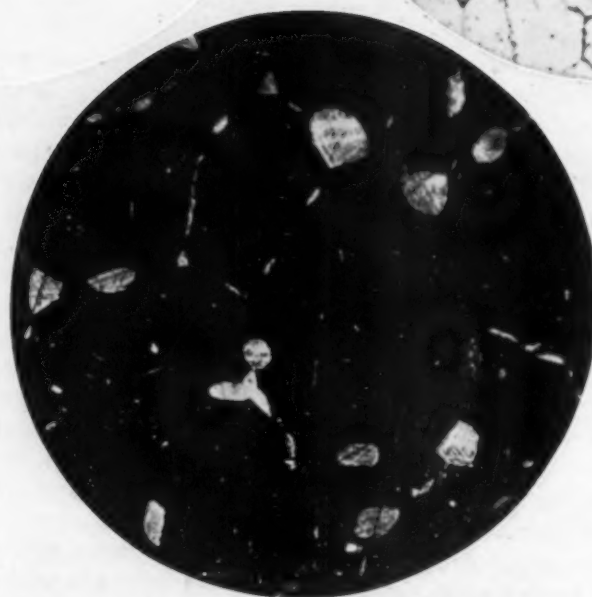


Fig. 3 (Center) — Normal Condition of Beta Phase Distribution in Average Material. Beryllium content of beta phase reduces the amount of beryllium available for hardening. Cross section, heat treated and etched; 250 diameters. (Courtesy Pease Laboratories)

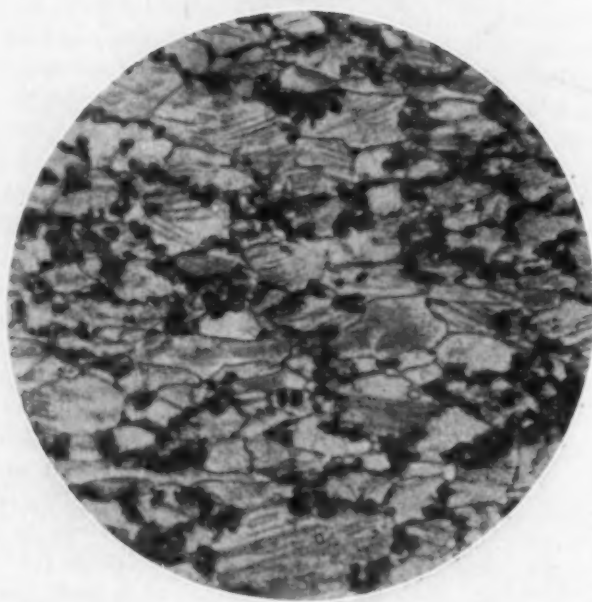


Fig. 4 (Below) — Complex Structure at Grain Boundaries Has High Beryllium Concentration, and Robs Alpha Phase of Its Hardening Constituent. Cross section, heat treated and etched; 500 diameters. (Courtesy L. B. Barker, Works Laboratory, General Electric Co.)

istics, but the only effect of the beta phase that we are interested in at the moment is that it lowers the available beryllium in the alpha phase. Since it does so in a varying degree, the available beryllium becomes an unpredictable factor unless the microstructure is examined. With excessive beta, an alloy containing 2% beryllium by analysis may have no more than 1.5% in solution in the alpha phase.

Another major source of loss in beryllium available for hardening is a condition variously described as "grain boundary precipitate" or "grain boundary gamma" as shown in Fig. 4. This formation is tied up with faulty mill practice, although the cause or composition of this boundary phase is not fully understood. Its

hardening rate as variations in beryllium content.

Beryllium distribution affects the performance of beryllium-copper in three ways:

1. Physical properties obtainable by heat treatment are directly affected by the amount of available beryllium rather than by total beryllium content.

2. Beta phase and the grain boundary constituent, in addition to reducing available beryllium, have detrimental effects on quality and performance of the alloy.

3. Amount of beryllium available for hardening has a large effect on the time required to reach maximum hardness.

No direct method of measuring the amount of available alloy has yet been developed. The

only practical solution to this problem is to determine the rate of response for each lot of material, and follow this test with examination of the microstructure on any lot having a low or slow hardening response. One or both the conditions shown in Fig. 5 may be responsible. Preliminary examination, lot by lot, or even of each coil of wire or rod is not too difficult nor expensive in the manufacture of high quality precision springs. Experience indicates, approximately, the optimum temperature for solution and precipitation,

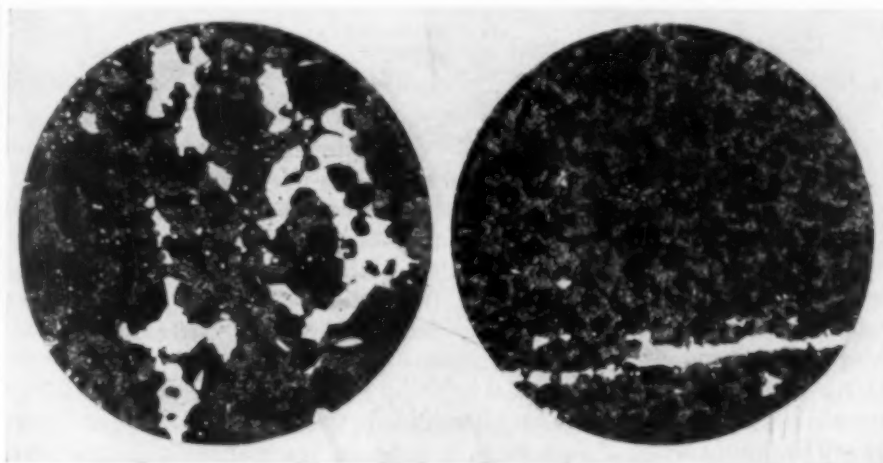


Fig. 5—Cross Section (at Left), and Longitudinal View of Same Specimen Showing Excessive Beta Phase and Grain Boundary Constituent. Although chemical analysis was over 2% beryllium, hardening response was no higher than for a 1.5% alloy. Magnification: 250 diameters. (Instrument Specialties Laboratory)

effect is to form clumps or masses of a phase along the grain boundaries that have many undesirable consequences, among them excess distortion of the piece when heat treated. But this phase does contain a high per cent of beryllium which reduces the amount of beryllium in solution and available for hardening.

Beryllium content has an important effect on the rate at which precipitation hardening takes place. Masing and Dahl, in work reported in 1928 and described in Rimbach's translation of the book "Beryllium and Its Alloys", found that an alloy containing 2.39% beryllium heat treated at 660° F. reached peak hardness in 1 hr., while an alloy with 1.82% required 9 hr. at the same temperature. Our own experience has shown similar effects at both higher and lower temperatures; also that variations in beryllium available for hardening have the same effect on

as it varies with size of part and specified service requirements. Then a series of small samples from each test lot are heat treated, the only variable being time at temperature for precipitation, and a hardness-time curve drawn from the results. Exact treatments can then be planned for those coils whose curves indicate an equivalent response.

When the material reaches the form of finished wire or strip, no corrective measure short of a full anneal can be helpful, and at this stage even an annealing operation will usually have but small effect. If each lot is tested for hardening response, it can then be heat treated at the one time and temperature to give best performance. No standardized heat treatment can be expected to develop desired properties unless the beryllium available for hardening is specified and controlled in mill fabrication.

Strong, Fine Wire; Non - Magnetic

Manufacture of Fine Wire of Hadfield's Manganese Steel

By Herbert H. Uhlig
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A CRITICAL SHORTAGE of chromium and nickel has stimulated the use of manganese compositions wherever applications permit. Austenitic Hadfield manganese steel, containing 10 to 14% manganese and 1.0 to 1.5% carbon, is a logical substitute for many uses of austenitic 18-8 chromium-nickel steel. The manganese alloy, although not corrosion resistant, possesses mechanical properties equal to 18-8 and is non-magnetic as quenched and after cold work. Stainless 18-8, on the other hand, becomes magnetic upon cold working. Chromium-nickel alloys of this general composition must contain as much as 12% nickel¹ in order to remain practically non-magnetic to the same degree as the Hadfield manganese steels.

However, wires of Hadfield manganese steel, high in carbon, are difficult to prepare because of the severe work hardening properties of the alloy. Brinell hardness may rapidly increase from 180 for the quenched alloy to 450 or even 550 after cold work. The low carbon 12 to 14% manganese-iron alloy, on the other hand, does not work harden to nearly the same degree, and consequently is easily drawn into wires of small diameter. These cold drawn wires are largely ferritic and appreciably magnetic. To obtain the desirable properties of the austenitic alloy, it is possible to carburize the low carbon wires, particularly if the diameter is small, in a manner

¹J. B. Austin and D. S. Miller, *Transactions*, Vol. 28, 1940, p. 743.

which is described below. The austenitic wire obtained by carburization must be further cold drawn to size in order to achieve highest strength. This is accomplished without difficulty in a small size wire. The final wire possesses a tensile strength of the order of 300,000 psi. for 10-mil (0.010-in.) diameter, and is practically non-magnetic.

Low carbon manganese-iron wires for this investigation were drawn from swaged ingots cast from a heat of electrolytic iron and electrolytic manganese. The analysis showed 14.4% manganese and 0.03% carbon.

Wires of this composition, 20 mils in diameter, were carburized in a mixture of hydrogen and xylene. This was done by suspending the wire in a horizontal pyrex tube and heating to 1000° C. (1830° F.) by passing a constant electric current (10.1 amp.). Temperatures were determined by an optical pyrometer. Interrupting the current through the fine wire, surrounded in the cold hydrogen-xylene atmosphere, was the same as a rapid quench. Carburization equivalent to 1% carbon absorption required only 1 min. at 1000° C., but the carbon so absorbed resided largely in a surface layer of the wire as the photomicrograph of Fig. 1 proved.

To diffuse this carbon to the center, the wire was heated an additional 3 min. at 1000° C. in a dry hydrogen atmosphere. Hydrogen purified by copper at 400° C. (750° F.), and dried by passing over P₂O₅ and through a liquid air trap, was found to have only a slight decarburizing action. This was checked by careful weighings of wires before and after homogenization, and is the expected behavior of dry hydrogen from previous

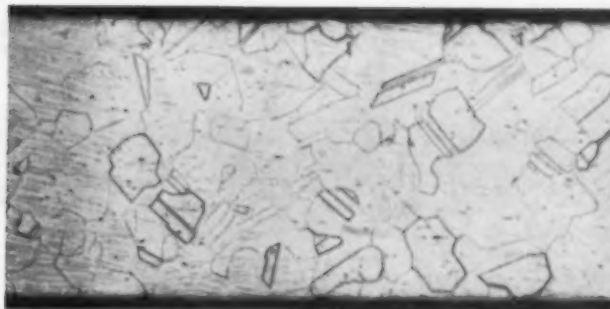
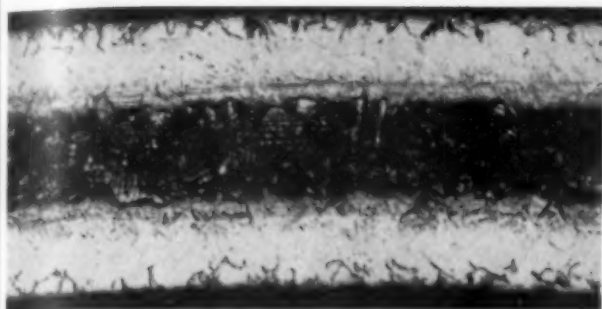


Fig. 1 — Alloy Made of Electrolytic Iron and Manganese Carburized in Gas, 1 Min. at 1000° C. Magnified 100 dia. Fig. 2 — Homogenization for 3 Min. at 1000° C. Produces Uniform Austenite (0.97% carbon.) Micros by Constance Brodie

investigations of the decarburization of iron.² Micros of wires so homogenized showed that the alloy was completely austenitic (Fig. 2).

Mechanical properties of wires carburized in this manner are given in the table. An 18-8 composition (19% Cr, 9% Ni, 0.8% Cb, 0.07% C) is included for comparison. Magnetic attraction designated "nil" was for wires which, when suspended, were not attracted to a "C" alnico magnet measuring 2¾ in. at the largest diameter. "Slight" indicated some attraction, but not enough to support the weight of a piece about 1 in. long. "Magnetic" was applied to wires which in 1 in. or longer lengths could be picked up.

The tensile strengths of quenched 20-mil wires were considerably increased by cold drawing to 10 mils, but decrease in elongation accompanied the strengthening. The 18-8 alloy became magnetic by this process, independent of previous treatment. The Hadfield alloy gained only slight magnetism (Wire A in the table), and even this was avoided when the 20-mil wire was pickled before the cold drawing operation (Wire B).

The effect of pickling to insure a non-magnetic cold drawn wire is explained as follows: It is probably connected with some loss of car-

bon and evaporation of manganese that takes place during the heat treatment. It was possible to detect manganese chemically in a slight film which condensed on the pyrex tube. The loss occurs at the wire surface leaving a superficial layer of alloy too low in manganese or carbon or both to remain as austenite when plastically deformed. This slightly magnetic layer is removed by pickling in dilute sulphuric acid.

The small time factor necessary for carburizing and homogenizing suggests that both of these operations can be combined in a continuous process. Wires heated by an electric current can move directly from the hydrocarbon atmosphere into pure hydrogen, for homogenization. To increase mechanical strength it is feasible to pass the wire finally through a cold die before the wire is wound on a reel.

Summary — Non-magnetic wires of difficult-to-draw Hadfield manganese steel can be produced by carburizing the easier drawn, low carbon manganese-iron alloy. Gas-phase carburization, followed by homogenization at 1000° C., required only 4 min. for 20-mil wire. The resulting wire contained about 1% carbon and was completely austenitic. A 75% reduction of area yielded non-magnetic wire, having a tensile strength of the order of 300,000 psi., which can be substituted for critical 18-8.

²J. V. Emmons, *Transactions, Am. Inst. Mining & Met. Engrs.*, Vol. 50, 1915, p. 405. C. R. Austin, *Transactions*, Vol. 22, 1934, p. 31.

Properties of Carburized 14.4% Manganese-Iron Wires Compared With 18-8

WIRE	CARBON	TENSILE STRENGTH PSI. x 10 ⁻³		ELONGATION		MAGNETIC ATTRACTION		TREATMENT
		10-MIL	20-MIL	10-MIL	20-MIL	10-MIL	20-MIL	
A	0.97%	144	133	70%	51%	nil	nil	Quenched from 1000° C.
		284		5		slight		Same, cold drawn 20→10 mils
B	1.05	141	129	66	50	nil	nil	Quenched from 1000° C.
		324	approx. 0			nil		Same, pickled, cold drawn
18-8	0.07	101		25		nil		Quenched from 1000° C.
		211		3		magnetic		Same, cold drawn

Defects in Magnesium Castings

From Poor Heat Treatment

By Roy B. McCauley, Jr.,
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DEFFECTS in magnesium castings, due primarily to incorrect heat treatment, may be briefly listed in the following tabulation, repeated from the first instalment of this article:

Lack of solution	Too short time of treatment or too low temperature.
Eutectic melting	Too high temperature of treatment; too rapid rise to heat treating temperature.
High temperature deterioration	Water in the furnace; lack of protective atmosphere.
Warpage	Internal tensions; improper loading or poor support in furnace during heat treatment.
Grain growth	Cold straightening, or other causes of excessive residual stresses occurring prior to heat.

These matters will now be examined in some detail, and illustrations given.

Lack of Solution—Two types of incomplete solution can be distinguished; the one caused by too short a time and the other caused by too low a temperature of heat treatment. The first is shown, microscopically, in Fig. 17.* Solution has taken place but is not completed on account of the short time, and some of the soluble constituent is left undissolved, forming a complete network at the grain boundaries.

The second type is shown in Fig. 18—very little constituent is dissolved and a pronounced coring is revealed by etching. Re-precipitated phases can also be seen at grain boundaries.

*Illustrations in the two articles are numbered serially.

An article in the May issue listed the causes and cures of common defects in magnesium sand castings arising from aberrations in molding, melting, pouring and solidification. About five additional troubles may arise in a good casting if the subsequent heat treatment is improper, and these will now be discussed briefly.

In both cases the mechanical properties of the casting will be low, lower in the second case because the alloy had been annealed, rather than solution treated. Low mechanical properties will be the first indication of improper heat treatment. The microscope will then detect the cause. Once

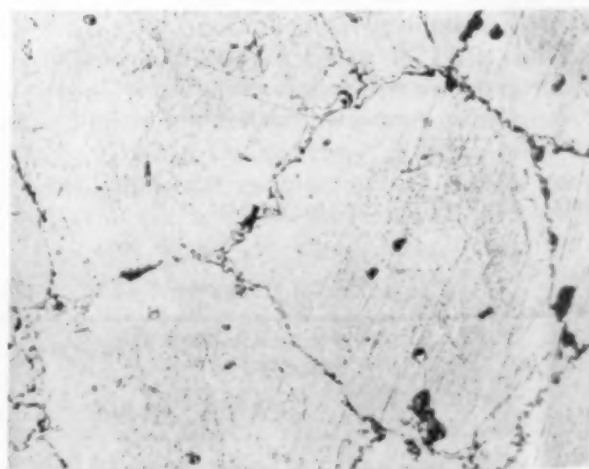


Fig. 17—Incomplete Solution; Too Short a Time of Heat Treatment. Microscope shows thin network of AlMgZn constituent at the grain boundaries, typical of this defect. Magnified 250 diameters; etched with 1% nital

the cause is found the correction is obvious. When lack of solution is detected, castings can be heat treated again. Amount of constituent not dissolved, importance of the casting, heat treatment facilities, urgency of the shipment will decide if these castings should be heat treated for a limited time or for a complete cycle.

Eutectic Melting — If the heat treatment temperature is too high, so as to surpass the lower melting point of the alloys, the eutectic will melt. Eutectic melting can also be produced by too fast a rate of heating to the heat treatment temperature, even if the right temperature is not surpassed. This odd behaviour is due to the presence of segregations of zinc, which will cause the formation of the constituent MgZn, in the place of the ternary AlMgZn. The binary constituent, which should not be present, will form a eutectic with magnesium which has a melting point below the recommended heat treatment temperature. If the heat treatment is done by steps with a slow temperature rise, that constituent has time to be absorbed into solution and the low melting eutectic will not appear.

Eutectic melting is rather difficult to detect in mild cases. The mechanical properties are only slightly lower than usual and micro-examination will reveal only few spots (as the one in Fig. 19) which indicate either eutectic melting or porosity in the casting itself. In serious cases the casting starts to melt and even burns, and then it is a problem for the fireman rather than for the metallurgist! Castings in which eutectic melting has taken place cannot be salvaged other than by remelting.

Fig. 18 — Incomplete Solution Caused by Too Low Temperature. The rounding of the constituents (especially of the pearlitic type of eutectic, here visible as black points) is typical of this defect. Also notice coring of the solid solution. Magnified 250 diameters; etched with 1% nital

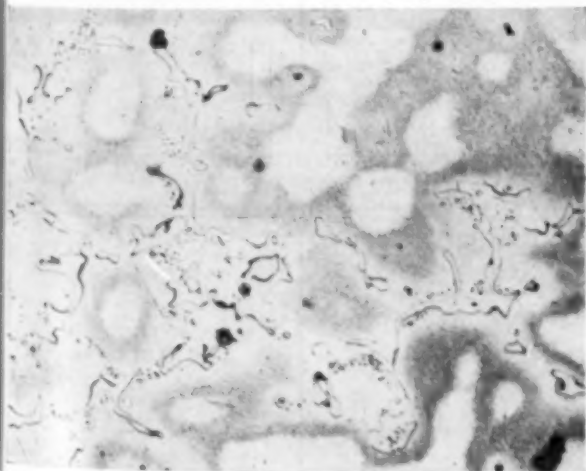


Fig. 19 (Below) — Eutectic Melting Has Caused the Dark Lines and Spots Visible in This Casting. Magnified 100 diameters; glycol etch

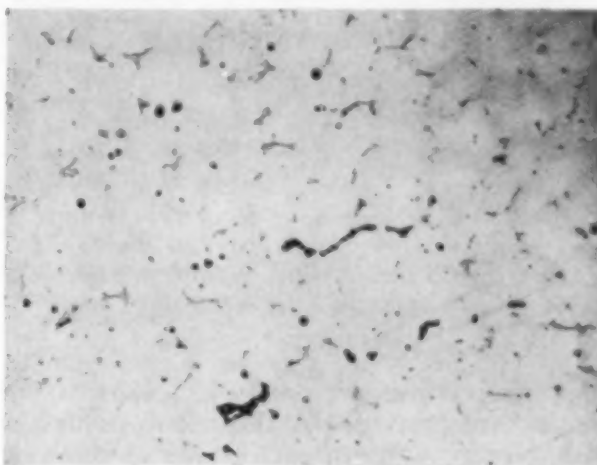


Fig. 20 — High Temperature Deterioration Along Micro-Shrinkage Cracks Is Revealed by the Yellowish-Brown Oxides in the Print. Magnified 100 diameters; not etched

High Temperature Deterioration — Another defect, which commonly is associated with eutectic melting under the common name "burning", is more properly called high temperature deterioration. The two defects are different as to aspect and, although they are sometimes associated, arise from different causes. Figure 20 shows the microstructure of a casting in which high temperature deterioration has taken place.

Serious cases can be detected also by visual examination as a blackened zone on the casting. Also, the fracture will reveal it. Figure 21 shows two spots where high temperature deterioration has gone almost through a casting. It tends to follow micro-shrinkage since the effect is a corrosion effect, caused by the oxidation of porous material by the air entrapped therein.

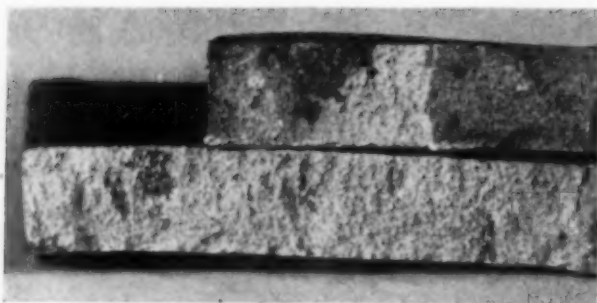


Fig. 21 — Severe Cases of High Temperature Deterioration, as Shown by the Blackened Spots Inside the Casting. (Darker zone in the right of upper piece is a hot-short crack)

X-rays are of little use in the detection of high temperature deterioration, because it is impossible to distinguish it from micro-shrinkage.

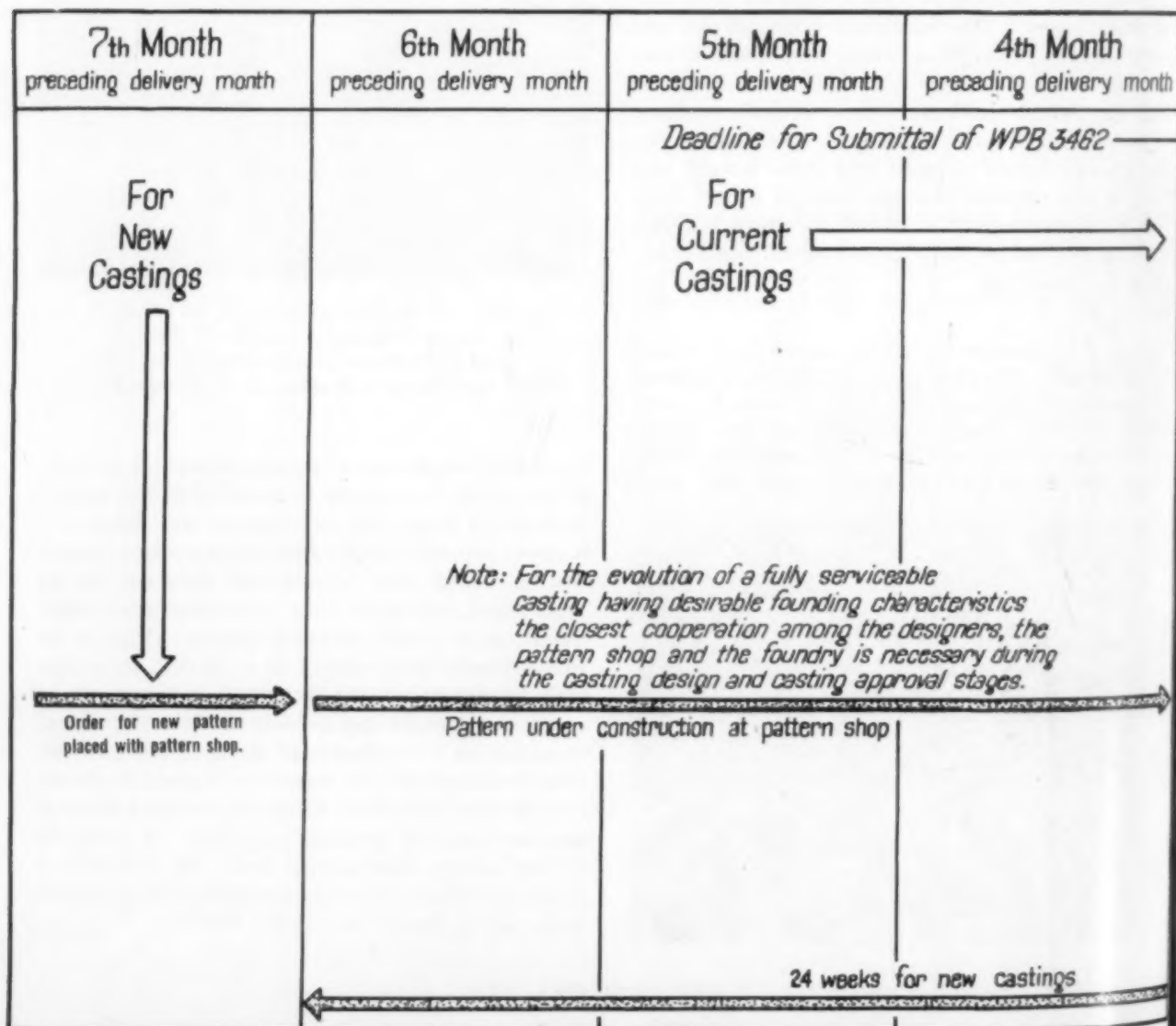
Warpage—Magnesium castings at the heat treatment temperature are quite soft and if not carefully placed on racks will tend to settle. If

warpage is serious, it may be necessary to resort to an annealing-straightening operation before the solution treatment.

Grain Growth—Magnesium alloys are rather susceptible to grain growth. As in steel and other alloys, a "critical" combination of plastic deformation (which need not be very great) and temperature will cause the formation of very large grains. Cold working followed by heating, as for instance cold straightening before solution heat treatment, may cause grains to grow even to 1 or 2 in. in diameter. Figure 22 shows an instance where cold work has produced twinning and grain growth. Grain growth may also occur on areas drastically chilled in the mold, when subsequently heat treated. Furthermore it will occur more readily in alloys high in aluminum, which require higher solution temperatures.

Conclusion—Our aim in these two contributions has been to describe those defects which are so common, both in frequency and in quantity, as

Time Cycle for Procurement of Typical Aircraft Castings



to constitute a problem from a production point of view. Many more defects may be found in magnesium castings, but it would be useless to try in these pages to expound the whole metallurgy of magnesium.

We hope that this paper will prove useful to those people who are now engaged on production of magnesium castings, and cannot take time out to investigate defects at their leisure, but must correct them as soon as they appear, and keep the castings flowing to the assembly lines.

We also hope that this emphasis on number and variety of defects will not create the impression that magnesium castings are inherently unreliable and should be avoided. Most of them are serious during the days when a new organization is learning how to cast these new alloys, strange in many respects. As was shown in Dr. Krivobok's article last month (page 1110) foundry rejects rapidly dropped as experience in production was gained.

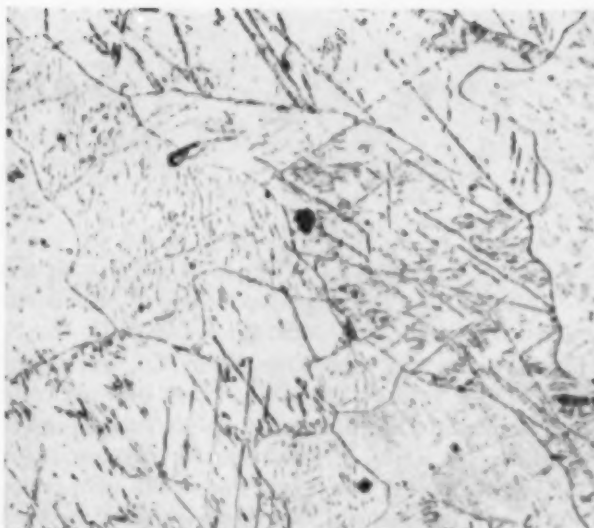
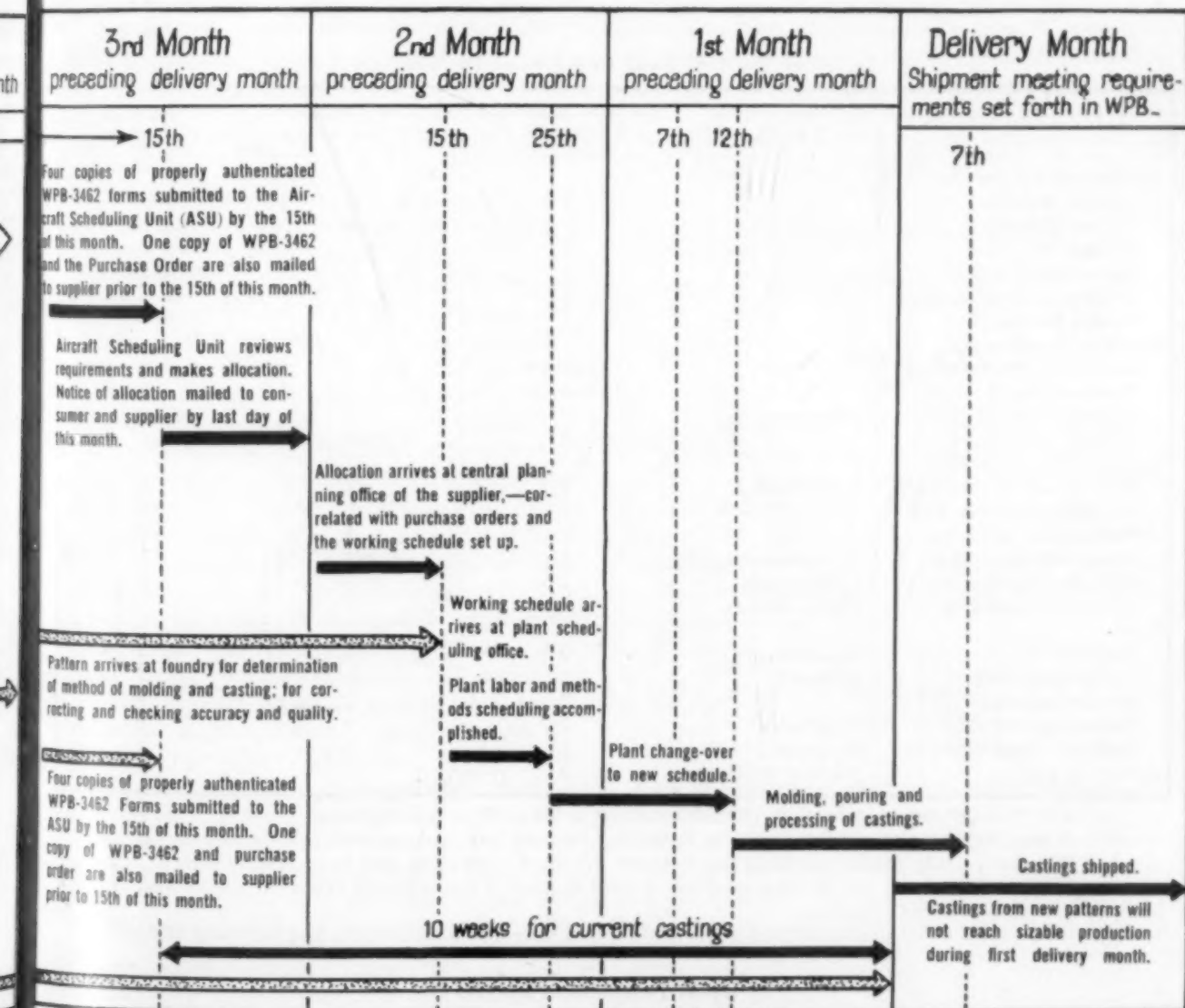


Fig. 22 — Casting Badly Distorted and Straightened Before Heating, Resulting in Coarse Grains, Slip Lines and Strain Bands. Magnified 25 diameters; etched with 1% nital

Castings of Magnesium Alloy, Weighing Over 5 Lb.

By Allied Aircraft Production Board
(Scheduling Unit) Wright Field, Dayton, Ohio



Selection of Die Castings

WHILE discussing the "Post-War Outlook for Zinc Alloy Die Castings" before the April meeting of the American Zinc Institute, S. E. Maxon of New Jersey Zinc Sales Co. presented the attached interesting table. In it he ranks the four principal families in an approximate order of merit. In using it as a selector, the engineer should give prime consideration to the properties that *must* be secured, and the conditions that *must* be met. *Desirable* properties should then be given attention.

"Generally speaking, zinc alloy die castings give lowest overall cost, because of the many favorable properties by which they have gained widest use by a 3 to 1 margin over all others combined. Magnesium or aluminum alloys are commonly chosen when light weight is essential, and the brass alloys are chosen chiefly where a

maximum in mechanical properties is demanded or where exceptional corrosion resistance is needed, since costs are rather high.

"Zinc alloys weigh about $2\frac{1}{2}$ times as much as aluminum alloys, and under some market conditions the metal going into a given casting costs less in aluminum than in zinc alloy. Yet over a period of several years the *total* cost of zinc alloy castings has been nearly always well below that for an identical casting in aluminum alloy. The reason lies largely in the higher die maintenance and casting costs for the aluminum alloy, although other factors such as easier plating and the higher strength of the zinc alloys also influence its choice. Furthermore, because of their higher melting temperature, aluminum castings require a longer cooling period in the dies, and this slows down production rates."

Order of Merit of Four Families of Die Castings

SELECTION FACTOR	ZINC ALLOYS A.S.T.M. 21, 23, 25	ALUMINUM ALLOYS A.S.T.M. 5, 7, 12	MAGNESIUM ALLOYS A.S.T.M. 12, 13	COPPER ALLOYS (BRASS)
<i>Mechanical Properties</i>				
Tensile strength	2	3	3	1 (strongest)
Impact strength	2	3	3	1 (toughest)
Elongation	2	4	3	1 (most ductile)
Dimensional stability	3 (a)	2	3	1 (most stable)
Resistance to cold flow	3	2	2	1 (most resistant)
Brinell hardness	2	3	3	1 (hardest)
<i>Physical Constants</i>				
Electrical conductivity	2	1 (highest)	3	2
Thermal conductivity	3	1 (highest)	4	2
Melting point (b)	1 (lowest)	2	2	3 (highest)
Weight, per cu.in.	3	2	1 (lightest)	4
<i>Casting Characteristics</i>				
Ease, speed of casting	1 (easiest)	2	2	3
Maximum feasible size	1	1	1	2
Complexity of shape	1	1	1	2
Dimensional accuracy	1 (most accurate)	2	2	3
Least section thickness	1 (thinnest)	2	2	3
Surface smoothness	1 (smoothest)	2	2	3
<i>Cost</i>				
Die cost (c)	1 (lowest)	2	2	3
Production cost	1 (lowest)	2	2	3
Machining cost	1	2	1	3
Finishing cost (d)	1 (lowest)	3	3	2
Cost per piece (e)	1 (lowest)	2	2	3
<i>Extent of Use</i>	1 (most used)	2	3	4

(a) A low temperature annealing virtually stabilizes Alloy 23 in dimensions.

(b) A low melting point is favorable in reducing die cost and upkeep and facilitates casting.

(c) Dies for casting the low melting point alloys are least expensive and have longest life.

(d) Includes polishing and buffing expense as well as ease of applying all types of commercial finishes, both electrodeposited and organic.

(e) Based on die, material and fuel costs, production speed, and machining and finishing costs.

Measurement of Case Depth

by Hardness Gradient

By Thomas C. Fazio

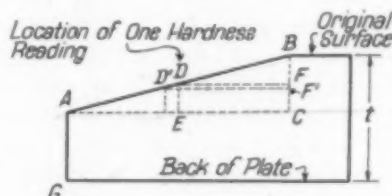
Metallurgist, Armor Division
Breeze Corporations, Inc.
Newark, N. J.

CASE DEPTHS of carburized steels are usually obtained by carbon analyses of successive individual lathe or miller cuts which vary from 0.005 to 0.015 in. deep. This laboratory method, applied to both flat and round stock, is the most accurate and direct means of measuring carbon penetration.

In our laboratories where a great many such determinations are required, the above method proved tedious. Our investigations of carburization characteristics of armor plate analyses, as affected by temperature, composition of carburizing media, energizers, and other factors, resulted in such a large number of tests that a rapid method of case depth measurement was desired. Either visual or microscopic examinations of etched samples were only qualitative, and subject to inaccuracies due to the unpredictable behaviour of an etchant. A hardness gradient of a taper-ground specimen, hardened in a standardized manner, was found to be adequate, since it affords rapid, accurate and comparative results.

Hardness gradient is obtained in very simple fashion using the "photoslope" method. This involves measuring the Rockwell "C" hardness on a sloping plane which is ground at a small angle to the original surface. Any point on the slope then represents a particular depth below the surface, the depth being a constant fraction of the distance between the point of impression and the intersection of the plane of the slope with the original face. In the testing operation, indentations are taken at intervals down the slope and the sloped surface photographed. The

distance between each impression and the top of the slope is tabulated with the respective hardness value. The product of this distance and a derived constant gives the depth. The sketch below shows how this constant k is derived, and is independent of the magnification or reduction of the photograph. Obviously, also, the standard taper-ground piece can be placed on a simple fixture with a verniered traverse, and hardness readings taken at uniform intervals representing any desired series of depths.



In the above sketch, showing the cross-section of the test piece, AB and BD are measured on the photograph. BC is the difference between the original thickness t and the micrometered distance AG . We wish to know the depth below the original surface of the hardness impression D , or the distance BF . From similar triangles we equate the ratios

$$\frac{BF}{BD} = \frac{BC}{AB} = k$$

Solving, $BF = k \cdot BD$

Likewise, $BF' = k \cdot BD'$; etc.

A photograph from one of the tests is shown on page 90; significance of the notation is obvious. Any number of parallel rows may be taken on one sample depending upon the precision required. For the above method a fixture for grinding is desirable, and a base with similar

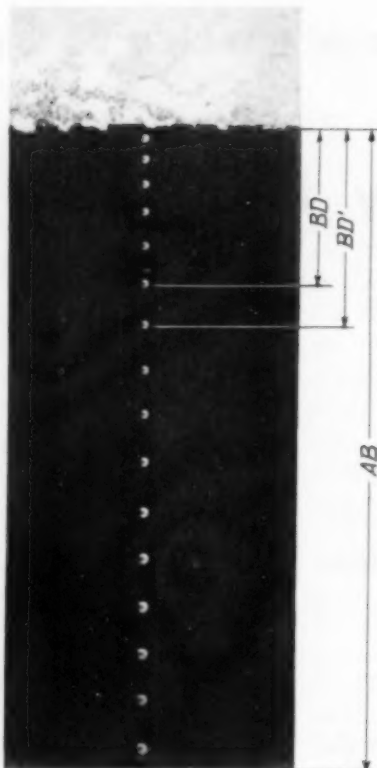
taper is necessary for the hardness tester, where accurate values are important. The hardness fixture's base is ground at an angle such that the standard penetrator is perpendicular to the surface being tested.

The final test piece measures approximately $\frac{3}{4}$ in. wide and 2 in. long. To avoid an edge effect, a 9x9-in. plate is carburized. This plate size is also necessary so that a constant mass action effect will occur during quenching. The plate is thoroughly grit blasted, copper plated on one side and carburized for the desired length of time. We then normalize (air cool)

from carburizing temperature, reheat in a neutral salt bath furnace and quench in oil at 130° F.

After hardening, a 2½-in. square is cut from one of the bottom corners. Two ½-in. edge strips are discarded, leaving enough material for the hardness gradient sample (½x2 in.), and a carbon gradient sample (1½x2 in.) if required. All cutting is done on a wet Carborundum wheel. With the aid of a tapered fixture as a base, to give the required angle of approximately 4°, the hardness specimen is surfaced on a surface grinder (magnetic chuck type, run wet) to cut 0.15 to 0.16 in. deep, or slightly beyond the total case depth, whatever it may be. This is an important step. A few thousandths are cut at one time to prevent overheating.

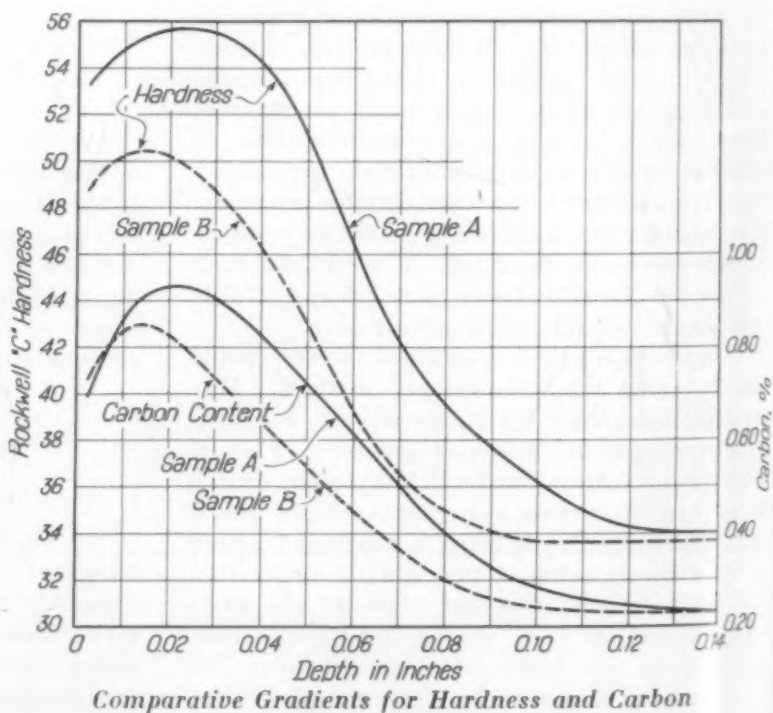
To orient our tests a number of samples, representing mean and extreme conditions, were surveyed for hardness penetration as described, and the results correlated with carbon analyses of thin layers cut parallel to the carburized surfaces. Two typical hardness gradients are shown in the accompanying graph. Comparing these with the carbon



gradients, it is seen that the position of the maximum carbon is the same as for the maximum hardness; also the depth at which the hardness gradient tapers off checks well with the carbon-penetration curve. A considerable quantity of such evidence has taught us to rely upon the hardness test alone. The important characteristics we wish to know about a carburized case are (a) the depth at which the hump of the carbon gradient occurs (b) the depth at which the curve levels off, indicating the effective case.

Photograph of a Hardness-Penetration Test Piece, Taper Ground and Tested at Intervals. Record made by projecting the image directly on bromide paper and developing; negative and reversal is unnecessary

Hardness gradients have afforded us a rapid and accurate means of measuring case depths in carburized armor. Furthermore, they have been of value in detecting small amounts of retained austenite in high carbon cases, and, also, in the study of quenching characteristics. (It is planned to discuss these matters in a later communication.) The method can also be used to good advantage in determining the extent of decarburization for homogeneous and face hardened steels after they have gone through the various heat treating cycles.



Index of Uses for National Emergency Steels

Compiled by
Research Dept.
Bethlehem Steel Co.

*Alphabetical list by uses
on pages 95 and 96. For
chemical specifications and
hardenabilities of NE steels
see Data Sheet, page 96-B*

NE 1320

Drive pinions
Ring gears

NE 1330

Axle shafts
Bolts
Camshaft rocker levers
Cranes
Crankshaft forgings
Differential gears
Forgings, aircraft
Forgings, locomotive
Fuse wire
Grousers
Jigs, machine tools
Keys, machine tools
Link pins, doors, hatches
Pneumatic drill handles
Propeller shafts
Ring gears
Ship insulating cowls
Spindle shafts
Starting motor shafts
Steering knuckle supports
Studs, cylinder head
Tractor parts
Turbines
Vibration damping mountings

NE 1335

Bolts, diesel engine
Chains
Cold headed or forged parts
Connecting rod bolts, diesel engine
Differential ring gears
Gear forgings
Keys, machine tools
Oil well sucker rods
Operating levers
Piston rods
Steering arms
Studs, auto
Wrenches

NE 1340

Air brakes
Axle shafts, truck
Bevel gears
Carburetor parts
Chain appendages
Chain side bars
Compressor valves, mine
Cranes
Cylinder head studs
Diesel engine parts
Diesel lock ring bolts
Elevator shafts
Engine stand bolts

Fabrication nuts and bolts
Forgings, aircraft
Jack hammer bolts, mine
King pins, auto
Locomotive nuts
Milling cutter bodies
Nuts
Oil pump shafts, truck
Pinion gears
Rocker arms, aircraft
Screws; set screws
Shafts
Steering arms
Steering knuckles
Structural members
Studs
Tractor shafts
Transmission gears
Wrenches

NE 1342

Transmission gears

NE 1345

Axle shafts
Axles, trailer
Bevel gears
Bolts
Bolts, high temperature
Camshaft rocker levers
Cargo hoists
Chain, mine
Chain rollers
Chain terminals
Chemical tanks
Clutch shafts
Cold headed or forged
Collars, drill
Connecting rod bolts
Coupling bolts
Crankcase studs
Cracking still fittings
Crankshaft extension bolt
Dowel bushing

Draw bench mandrels and punches
Drill collars
Engine ring mounts
Engine spacers
Flame hardened objects
Forgings, aircraft
Hammers
Joints, oil well tool
Lever shafts
Lock nuts
Magneto coupling screw
Main bearing bolts
Nuts
Oil seal ring housing liner
Oil seal ring spacer
Oil well tool joints
Pinion shafts
Pinions and axles, mine
Piston rods
Screw machine parts
Screws
Spring cross shafts
Steering arms and knuckle supports
Studs, high temperature
Supercharger shaft
T-bolts
Transmission gears
Tread chains
Turbines
Valve spring collar key
Valve spring washers
Winch gears
Windlass shafts
Wrenches, tank

NE 1350

Clutch spring bolt, auto
Conveyors
Drill stems
Flat springs
Gears
Hoist parts

NE 1350 (Cont.)

Jack hammer valves
Retractor slides
Rock drill chucks, mine
Roller compression
springs
Screws
Shafting
Shafts, machine tools
Springs, flat and leaf
Sprocket shafts
Steam pipe bolts
Steam turbine bolts
Tools, track
Tractor parts
Valve tappets
Yokes, shifter

NE 8020

Armature pinions, mine
Boiler studs, locomotive
Chain knuckles and pins
Differential pinion gears
Drifter feed screws, mine
Handles
Jigs, machine tools
Piston pins
Pitman shafts
Pivot pins
Rifle bars, mine
Rock drill chucks, cylinder covers, hose connections, throttles and reamers
Shafts, main transmission
Side gears
Steering arm bolts, studs
Steering ball joints
Tooth followers
Transmission gears
Tread chains
Turret lathe collets
Valve tappets

NE 8022

Boiler studs, locomotive
Chain knuckles and pins
Differential pinion gears
Drifter feed screws, mine
Drive pinions
Jigs, machine tools
Pipe wrench handles
Piston and pivot pins
Precision lathe parts
Rims, wheel
Rock drill parts (see NE 8020)
Shafts, main transmission
Shafts, pump
Side gears
Springs, leaf
Steering ball joints
Suction pump impeller
Tools
Transmission gears
Tread chains
Turret lathe collets
Valve tappets

NE 8339

Axle shafts
Connecting rod bolts, diesel engine
Milling cutter bodies
Piston rods
Rock drill chucks, mine
Studs, automobile
Wrenches

NE 8615

Tractor gears

NE 8620

Armature pinions, mine
Automobile bolts
Bakery equipment
Bearings, races and balls
Bolts
Brake assemblies
Camshafts
Chain pins
Chuck parts
Clutch fork lever pin
Collets, machine tools
Cranes
Crankshaft forgings
Diesel engine hubs
Differential gears, pinions and ring gears
Drifter chucks, mine
Drive pinions
Gears, for mining and road machinery
Jigs, machine tools
King bolts and pins
Knuckle pins
Machinery, mine
Main drive gear
Oil pump impeller shafts
Pinion gears
Piston pins
Pneumatic tools
Precision lathe parts
Reducing gears
Reverse gear lock ring
Reverse gear pinion shaft
Ring gears
Rock drill bolts, mine
Rotor nuts
Shafts, mine
Shoes, mine
Side gears
Slides, machine tools
Splines
Sprockets, mine
Spring hanger pins
Starter motor drive shaft
Starter motor pinion
Steering arms, automobile
Steering ball joints
Suction pump impeller
Transmission chains
Transmission machinery
Valve tappets
Vibration damper
Worm gears and shafts

NE 8630

Axle shafts
Bolts, diesel engine
Connecting rod bolts, diesel engine
Cranes
Dampener mountings
Fluid line fittings
Forgings, locomotive
Fuel pump sleeves
Jigs, machine tools
Keys, machine tools
King bolts
Link pins, doors, hatches
Piston rods
Spindle shafts
Starting motor armature shaft
Steering knuckle supports
Studs
Tractor parts
Tripods
Turbines

NE 8635

Chain appendages
Chain pins
Cold headed or forged
Keys, machine tools
Oil well sucker rods
Operating levers
Pinion gears
Socket wrenches
Steering arms

NE 8637

Diesel engines
Locomotive nuts
Reducing gears
Steering knuckles

NE 8640

Air brakes
Axle shafts, truck
Axles
Bevel gears
Bolts
Bolts, high temperature
Carburetor parts
Centrifuges
Chain rollers; side bars
Chemical tanks
Clam bucket teeth
Cold headed or forged
Collars, drill
Connecting rod bolts
Coupling bolts
Cracking still fittings
Cranes
Crankcase studs
Crankshaft extension bolt
Diesel lock ring bolts
Dowel bushing
Drill collars
Elevator shafts
Flame hardened objects
Forgings, aircraft
Hexagonal nuts

Magneto drive, coupling screw
Main bearing bolts
Nuts
Oil seal ring housing liner
Oil seal ring spacer
Oil well tool joints
Pinion shafts
Piston rods
Pump rotors
Screws
Set screws
Shafting
Steering arms
Studs, high temperature
Tractor shafts
Transmission gears
Transmission machinery
Transmission sprockets
Tread chains
Turbines
Universal joints
Valve spring collar key
Windlass shafts
Wrenches, tank

NE 8642

Cargo hoists
Clutch shafts
Draw bench mandrels and punches
Drill collars
Kelleys
Spring cross shafts
Transmission main shaft gear

NE 8645

Axles, trailer
Clutch shafts; clutch spring bolt, automobile
Differential ring gears
Drill stems
Lever shafts
Roller compression springs
Shafting
Springs, flat and leaf
Sprocket shafts
Steam pipe bolts
Steam turbine bolts
Steering arms
Tools, aircraft
Tools, track
Valve tappets

NE 8647

Tool holder studs

NE 8650

Axles
Conveyors
Generator shafts
Hammers
Launch gears
Piston pins
Shafting

NE 8715

Brake assemblies for automobiles
Cam shafts
Clutch fork lever pins for automobiles
Clutch pinion
Diesel engine hubs
Differential gears, pinion gears, ring gears
Drifter chucks, mine
Drive pinions
Forgings, aircraft
Gears for road rollers
Gears, mine
Gears, miscellaneous
King pins
Oil pump impeller shafts
Oil suction impeller
Pinion gears
Piston pins, diesel engine
Piston rings
Power boat transmission
Reducing gears
Reverse gear lock ring
Reverse gear pinion shaft
Rock drill hose connections and throttles
Rods, sucker
Slides, machine tools
Splines
Starter drives, motor drive shafts and pinions
Tool holder shanks
Tools, aircraft
Tractor gears
Transmission reverse gear
Vibration damper
Windlass
Worm shafts

NE 8720

Balls, bearing
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Bearings and races
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Crankshaft forgings
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Drive pinions
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King bolts and pins
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NE 8722

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NE 8724

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NE 8730

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NE 8735

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NE 8737

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NE 8739

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Fabrication and erection bolts and nuts
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Nuts
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Reducing gears
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NE 8740

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Oil well tool joints
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Steering knuckles and supports
Studs
Transmission gears

NE 8744

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Chain, rollers, terminals
Gears, machine tools
Machinery, mine
Pinions and axles, mine
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Press tie bolts

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NE 8745

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NE 8749

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NE 8750

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NE 8949

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NE 9260

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Diesel engine hubs
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Worm gears and shafts

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Steam turbine bolts
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Sprocket shafts
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NE 9450

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Axles, trailer
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Collets, machine tools
Conveyors
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Hoist parts
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Pinions and axles, mine
Pinions, drive
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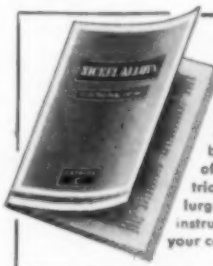
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National Emergency Alloy Steels*

Openhearth Alloy and Electric Furnace Alloy Steels; Blooms, Billets, Bars and Hot Rolled Strip.

Revised May 26, 1944

Adopted	Aban- doned	Designation	C	Mn	Si (a)	Ni	Cr	Mo	Hardenability (b)		Mo	Hardenability (b)	
									Low	High		Low	High
Carbon-Manganese Steels													
8/17/42		NE1330	0.28-0.33	1.60-1.90	0.20-0.35	(c)	(d)	(e)	1.53	4.24		2.20	6.60
8/17/42		NE1335	0.33-0.38	1.60-1.90	0.20-0.35	(c)	(d)	(e)	1.67	4.54		2.34	7.15
8/17/42		NE1340	0.38-0.43	1.60-1.90	0.20-0.35	(c)	(d)	(e)	1.80	4.79		2.60	9.20
8/17/42		NE1345	0.43-0.48	1.60-1.90	0.20-0.35	(c)	(d)	(e)	1.91	5.10		2.80	10.5
8/17/42		NE1350	0.48-0.53	1.60-1.90	0.20-0.35	(c)	(d)	(e)	2.02	5.39		3.36	
Carbon-Chromium Steels (f)													
8/17/42		NE52100 C	0.95-1.10	0.25-0.45	0.20-0.35	0.35max.	0.40-0.60	0.08max.	1.19	4.0		1.15	3.52
8/17/42		NE52100 B	0.95-1.10	0.25-0.45	0.20-0.35	0.35max.	0.90-1.15	0.08max.	1.74	6.0 (g)		1.23	3.70
8/17/42		NE52100 A	0.95-1.10	0.25-0.45	0.20-0.35	0.35max.	1.30-1.60	0.08max.	2.40	8.7 (g)		1.34	3.99
Manganese-Molybdenum Steels													
8/17/42	8/15/43	NE8020	0.18-0.23	1.00-1.30	0.20-0.35			0.10-0.20				1.15	3.52
8/17/42	12/17/42	NE8022	0.20-0.25	1.00-1.30	0.20-0.35			0.10-0.20				1.23	3.70
8/17/42	12/17/42	NE8024	0.22-0.28	1.00-1.30	0.20-0.35			0.10-0.20				1.34	3.99
1/21/42	8/17/42	NE8026	0.24-0.30	1.00-1.30	0.20-0.35			0.10-0.20				1.43	4.17
1/21/42	8/17/42	NE8028	0.26-0.32	1.00-1.30	0.20-0.35			0.10-0.20				1.66	4.72
1/21/42	8/17/42	NE8030	0.30-0.36	1.30-1.60	0.30-0.35			0.10-0.15				1.72	4.80
1/21/42	8/17/42	NE8032	0.32-0.38	1.30-1.60	0.30-0.35			0.10-0.15				1.81	5.10
1/21/42	8/17/42	NE8034	0.34-0.40	1.30-1.60	0.30-0.35			0.10-0.15				1.88	5.25
1/21/42	8/17/42	NE8036	0.36-0.42	1.30-1.60	0.30-0.35			0.10-0.15				1.98	5.45
1/21/42	8/17/42	NE8038	0.38-0.44	1.30-1.60	0.30-0.35			0.10-0.15				2.03	5.60
1/21/42	8/17/42	NE8040	0.40-0.46	1.30-1.60	0.30-0.35			0.10-0.15				2.12	5.80
1/21/42	8/17/42	NE8042	0.42-0.48	1.30-1.60	0.30-0.35			0.10-0.15				2.18	5.90
1/21/42	8/17/42	NE8044	0.44-0.50	1.30-1.60	0.30-0.35			0.10-0.15				2.26	6.05
1/21/42	8/17/42	NE8046	0.46-0.52	1.30-1.60	0.30-0.35			0.10-0.15				2.30	6.15
1/21/42	8/17/42	NE8048	0.48-0.54	1.30-1.60	0.30-0.35			0.10-0.15				2.39	6.30
1/21/42	8/17/42	NE8050	0.50-0.56	1.30-1.60	0.30-0.35			0.10-0.15				2.99	8.30
Nickel-Chromium-Molybdenum Steels													
5/26/44		NE8612	0.10-0.15	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.07	3.68		0.15-0.25	
8/17/42	5/26/44	NE8614	0.12-0.17	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25				0.15-0.25	
8/17/42		NE8616	0.14-0.19	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.34	4.02		0.15-0.25	
1/21/42		NE8618	0.16-0.21	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.43	4.25		0.15-0.25	
5/26/44		NE8620	0.18-0.23	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.52	4.47		0.15-0.25	
5/26/44		NE8622	0.20-0.25	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.65	4.77		0.15-0.25	
5/26/44		NE8624	0.22-0.28	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.72	4.96		0.15-0.25	
5/26/44		NE8626	0.24-0.30	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.84	5.23		0.15-0.25	
5/26/44		NE8628	0.26-0.32	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	1.91	5.47		0.15-0.25	
5/26/44		NE8630	0.28-0.33	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.00	5.64		0.15-0.25	
5/26/44		NE8632	0.30-0.36	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.22	6.35		0.15-0.25	
12/12/42		NE8634	0.32-0.38	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.28	6.50		0.15-0.25	
12/12/42		NE8636	0.34-0.40	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.38	6.75		0.15-0.25	
12/12/42		NE8638	0.36-0.42	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.54	6.90		0.15-0.25	
12/12/42		NE8640	0.38-0.43	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.59	7.13		0.15-0.25	
12/12/42		NE8642	0.40-0.45	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.67	7.15		0.15-0.25	
5/26/44		NE8644	0.42-0.48	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	2.88	7.50		0.15-0.25	
5/26/44		NE8646	0.44-0.50	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.00	8.01		0.15-0.25	
5/26/44		NE8648	0.46-0.52	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.18	8.49		0.15-0.25	
5/26/44		NE8650	0.48-0.53	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.48	9.39		0.15-0.25	
5/26/44		NE8652	0.50-0.56	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.62	9.88		0.15-0.25	
5/26/44		NE8654	0.52-0.58	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.72	10.12		0.15-0.25	
5/26/44		NE8656	0.54-0.60	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.82	10.36		0.15-0.25	
5/26/44		NE8658	0.56-0.62	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	3.92	10.60		0.15-0.25	
5/26/44		NE8660	0.58-0.64	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.02	10.84		0.15-0.25	
5/26/44		NE8662	0.60-0.66	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.12	11.08		0.15-0.25	
5/26/44		NE8664	0.62-0.68	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.22	11.32		0.15-0.25	
5/26/44		NE8666	0.64-0.70	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.32	11.56		0.15-0.25	
5/26/44		NE8668	0.66-0.72	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.42	11.80		0.15-0.25	
5/26/44		NE8670	0.68-0.74	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.52	12.04		0.15-0.25	
5/26/44		NE8672	0.70-0.76	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.62	12.28		0.15-0.25	
5/26/44		NE8674	0.72-0.78	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.72	12.52		0.15-0.25	
5/26/44		NE8676	0.74-0.80	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.82	12.76		0.15-0.25	
5/26/44		NE8678	0.76-0.82	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	4.92	13.00		0.15-0.25	
5/26/44		NE8680	0.78-0.84	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.02	13.24		0.15-0.25	
5/26/44		NE8682	0.80-0.86	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.12	13.48		0.15-0.25	
5/26/44		NE8684	0.82-0.88	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.22	13.72		0.15-0.25	
5/26/44		NE8686	0.84-0.90	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.32	13.96		0.15-0.25	
5/26/44		NE8688	0.86-0.92	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.42	14.20		0.15-0.25	
5/26/44		NE8690	0.88-0.94	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.52	14.44		0.15-0.25	
5/26/44		NE8692	0.90-0.96	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.62	14.68		0.15-0.25	
5/26/44		NE8694	0.92-0.98	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.72	14.92		0.15-0.25	
5/26/44		NE8696	0.94-1.00	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.82	15.16		0.15-0.25	
5/26/44		NE8698	0.96-1.02	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	5.92	15.40		0.15-0.25	
5/26/44		NE8700	0.98-1.04	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	6.02	15.64		0.15-0.25	
5/26/44		NE8702	1.00-1.06	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	6.12	15.88		0.15-0.25	
5/26/44		NE8704	1.02-1.08	0.70-0.90	0.20-0.35	0.40-0.70	0.40-0.60	0.15-0.25	6.22	16.12		0.15-0.25	
5/26/44		NE8706											

Maximum Carbon in Carburized Cases

CLEVELAND, OHIO

To the Readers of METAL PROGRESS:

The discrepancy between the careful work reported by Floyd E. Harris on the maximum carbon in carburized cases, and the equally careful work by Robert W. Schlumpf (see April *Metal Progress*, page 683), needs a little discussion. I would certainly hesitate to discourage the use of Schlumpf's results, especially in predicting the results of carburizing in solid compounds.

Mr. Harris finds that surface carbons in his pieces, carburized in simple gas atmosphere, correspond closely to that represented by the A_{cm} line in the iron-carbon equilibrium diagram, and are the higher as the carburizing temperature goes up. Mr. Schlumpf finds, on the other hand, that S.A.E. 3115 carburized in sodium energized compounds had 3.10% carbon at its surface when carburized at 1500° F., 1.8% carbon when carburized at 1600° F., and about 1.2% carbon when carburized at higher temperatures. (There is no discrepancy in the results of these two investigators concerning the carbon-penetration curves below the surface; these depend on the diffusion of carbon—or carbide—in austenite. The difference exists in the carbon concentrated in the outermost layers.)

I know from my own experience that it is not a very difficult matter to get as high as 2.00% carbon in almost any grade of steel if the carburizing is conducted under certain conditions. I know of a practice at one company which is producing deeply cased shafts of S.A.E. 5130 with carbon content consistently greater than 1.7% in the outer 0.010 in.; specifications require a hardness of at least Rockwell C-68. This is done by carburizing at 1750° F. for approximately 8 hr. and then dropping the temperature to approximately 1500° F.

I have recently seen several examples where steels carburized at 1680° F. showed a carbon content approaching 2.00% at the surface. Some years ago, when using Houghton's hydrocarbonated bone black and attempting to keep under a

maximum of 1.05% carbon, and where each shipment was checked several times for case concentration by turning specially designed test samples and analyzing for carbon content, we would find cases up to 1.80%. These steels were mostly plain carbon S.A.E. 1020, although a considerable portion of the work carburized was S.A.E. 5120.

Possibly the normal fluctuation of temperatures in commercial operations may cause carbon to build up at the surface. It is possible to convert thin shim stock, 0.002 in. thick, to practically pure carbide (6.7% C) by carburizing at low fluctuating temperature. Also, it is practically impossible to carburize, in mass production, without some evidence of high concentration of carbide at the extreme surface. Likewise the temperature uniformity in most furnaces leaves much to be desired. This matter of temperature fluctuation in practical furnace work is something that probably has a major influence on carbon concentration at the extreme surface.

I have seen evidence of surplus carbide even in the nickel and nickel-molybdenum steels, which have the least tendency to form high carbon cases. In these steels it is very unusual to have a carbon content much over that indicated as in equilibrium at the carburizing temperature, yet I know of one metallurgist who was carburizing nickel-molybdenum gears at two temperatures, the first of approximately 1700° F. followed by a cooling to approximately 1200° F. and then by re-carburizing at 1500° F. for 4 hr., whereby he obtained a carbon content which exceeded 1.70% in the first 0.010 in. of case.

It is to be hoped that Mr. Harris will be able to investigate the conditions that cause such high carbon surfaces. Evidently the gaseous atmosphere he is now using does not do this, to any discoverable amount. However, I believe it equally true that pack carburizing at relatively low temperatures (say 1600° F. or less) will result in thin layers of excess carbide, and the carbon analysis at the very surface will be the higher as the temperature is lower.

HARRY W. MCQUAID
Assistant Chief Metallurgist
Republic Steel Corp.

A Versatile Non-Ferrous Etchant

PITTSBURGH, PA.

To the Readers of METAL PROGRESS:

It may be of interest to know that a simple etchant has been in general use for non-ferrous metallography. The etchant has the following composition:

Ferric chloride	5 gm.
Ethyl alcohol	96 ml.
Hydrochloric acid (conc.)	2 ml.

The ferric chloride is first dissolved in alcohol, and then the solution is acidified by the concentrated hydrochloric.

Notwithstanding the fact that there are a number of ferric chloride etching reagents commonly in use, the writer has not seen any mention of an etchant having the foregoing formula. It has been adopted because of its optimum etching performance, and is the result of much experimentation.

In employing the reagent, specimens may be etched either by light swabbing or by immersing with gentle agitation. The time may vary from one second to over several minutes, depending on the condition and composition of the specimen. Since the alcohol tends to evaporate from the solution upon standing in open dishes, the etchant should be replenished frequently, otherwise its performance will be impaired.

Excellent results have been obtained on a number of commercial and experimental non-ferrous alloys containing aluminum, copper, lead, magnesium, manganese, nickel, tin, and zinc. In general, it develops excellent structural detail with sharp grain boundary delineations, and avoids any staining which is normally to be

expected when working with most ferric chloride reagents. Moreover, the etchant is invaluable for removing with ease any flowed metal which often results from grinding and polishing operations.

Though not necessarily regarded as a standard ferrous etchant, it has been used with remarkable success in etching tempered manganese steels. For this purpose, the etchant satisfied us better than either nital, picral, sodium picrate, or Vilella's reagent. This finding seems to indicate that the reagent may be satisfactory for etching other ferrous alloys, and, therefore, its potentialities should not be overlooked whenever the conventional ferrous etchants fail.

LOUIS A. CARAPPELLA

Metallurgist

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Differential Hardening With High Frequency Current

PEORIA, ILL.

To the Readers of METAL PROGRESS:

In re-typing the manuscript of my notes on the above subject, a most regrettable insertion was made, and I have no explanation of how it ever got in there. I refer to the next to last sentence of the fourth paragraph on page 493 of the March issue, starting "Even greater hardened depths" This sentence does not belong there and is confusing to the most important part of the article, and I hope that those who retain their copies of *Metal Progress* will run a line through it.

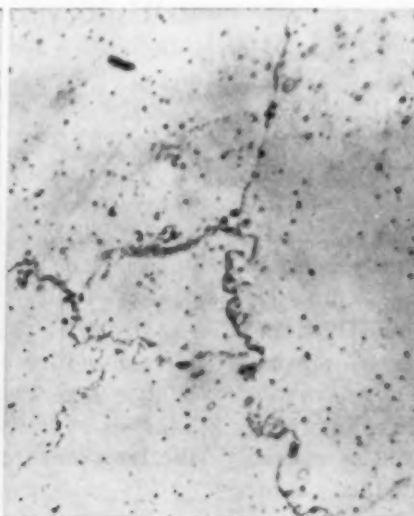
F. F. VAUGHN

Asst. Chief Metallurgist
Caterpillar Tractor Co.

Microstructure of Alloys Containing Increasing Amounts of Manganese



28.8% Mn



33.9% Mn



38.7% Mn

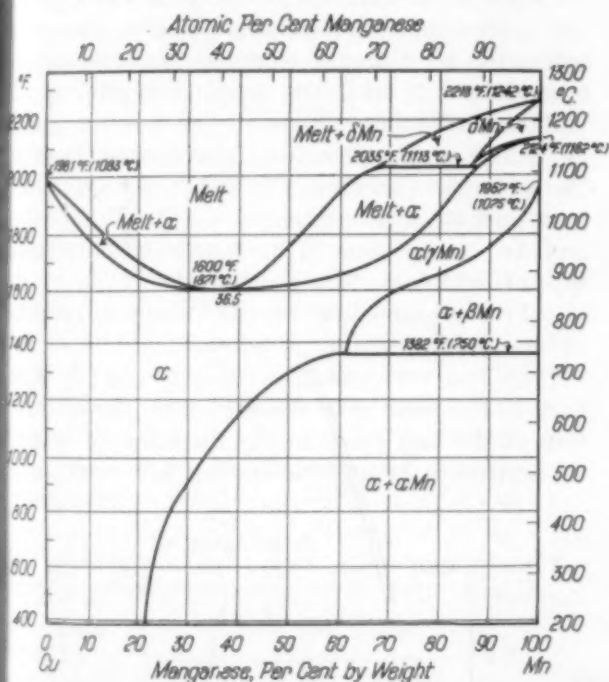
Indoor Sport

ROLLA, Mo.

To the Readers of METAL PROGRESS:

The recognized copper-manganese equilibrium diagram is as shown below, reproduced from page 527 of Sachs and Van Horn's book "Practical Metallurgy". For an indoor sport, try to outline a heat treatment, based on this diagram, which will produce the structures of the six alloys shown in the strip at the bottom of these two pages. They are all substantially pure binary alloys, manganese as noted, copper balance. All are reproduced at 250 diameters; all etched with the same reagent.

Copper-Manganese Equilibrium Diagram



Note the beginning of a change from alpha twins at 28.8% manganese, to something at 33.9% manganese which eventually develops into a eutectoid structure at 49% manganese. The amount of this finger-print or "thumb-line" structure increases as the manganese increases.

CHARLES Y. CLAYTON

Head

Dept. of Metallurgy & Ore Dressing
Missouri School of Mines

Armoring the President's Car

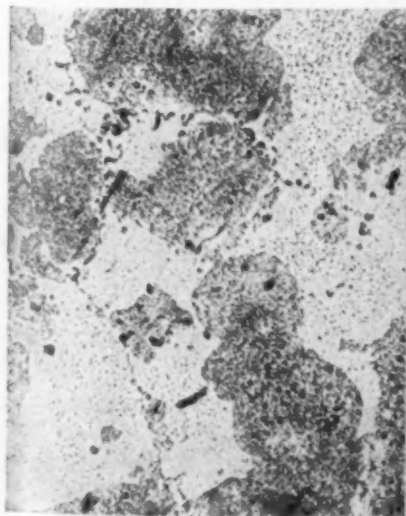
CAIRO, EGYPT

To the Readers of METAL PROGRESS:

About four days before President Roosevelt and his staff arrived for the Cairo conference with Prime Minister Churchill and his staff, last November, a secret service man drove a Packard sedan into the Base Automotive Maintenance Shops near Cairo and asked if we could make it thoroughly bullet and bomb proof. We could have not more than four days. Three would suit him even better.

The car was of standard U. S. Army style and paint job. The outside we didn't touch a bit; it didn't need any distinguishing marks. The driver's seat we didn't touch, either. But from the partition on back we took everything out carefully, upholstery and cushions and even the window-glass, and went to work.

We had no pattern to work by, but we had a definite idea of what was wanted: Protection first. That meant shielding the cab from any chance bullet from side or top or back, or from even an explosion from the bottom. But we had to leave the windows clear. The President wanted



43.8% Mn



49.2% Mn



59.5% Mn

to see and be seen. We had to give him an armored limousine, not a black-out car.

We made our patterns out of paper first and then plywood. Then we cut armor plate to fit, and stitched it in. It was a day-and-night job. During those three days we kept our Lincoln welder running 18 hr. a day. The armor was the stuff used to protect the nose of a P-38 or P-40 from bullets. Fortunately it was not put to a ballistic test when shielding the President!

As much as possible the protection was kept concealed and the whole job was neat and inconspicuous. Except for the weight and thickness of the doors, noticeable when you climb in, you are scarcely conscious that this car had been built over. The armor plate was welded in place, which was neat enough. Then the upholstery was put back and fastened, so the back seat would again be comfortable.

A small blower was built in to keep the air circulating, because the rear window was sealed over and the front and side windows covered with tight-fitting chunks of bullet proof glass.

From the outside the windows look about the same. Inside, however, the iron brackets supporting the heavy glass — welded in place — could not readily be concealed. After all, this was a matter of military safety; not something to do with a lady's boudoir. No one complained about the looks of the job, although the President did refer to the car as "the County Jail!"

L. L. WILKINSON

Lt., Ordnance Dept., U. S. Army

Temper Brittleness

SOMEWHERE IN FRANCE

To the Readers of METAL PROGRESS:

Temper brittleness, which occurs in some quenched and tempered steels when final cooling after tempering has been too slow, involves certain characteristics peculiar to quenching phenomena; the principal difference is that the effect is confined almost exclusively to the brittleness or, inversely, the steel's ductility.

It was therefore quite natural for Messrs. Jolivet and Chouteau to study the phenomenon by the same methods used so successfully to study the hardening process — namely, the isothermal decomposition of austenite at various temperatures. This brought out some new and interesting results:

For a given steel, brittleness after tempering appears to resemble the results from rapid quenching for hardening. Thus, a critical cooling velocity V_c marks the change from high ductility K_1 to a low ductility K_2 .

For our present purposes a steel can be char-

acterized by two coefficients or parameters:

1. The critical cooling velocity V_c for the appearance of brittleness, representing the sensitivity of the phenomenon.

2. Absolute susceptibility $S = K_1/K_2$, or relative susceptibility $\sigma = (K_1 - K_2)/K_1 = 1 - 1/S$, representing the intensity of the phenomenon.

This coefficient S is the only one that has formerly been considered, and it has been measured quantitatively, if at all, after holding in a temperature range of 500 to 550° C. (925 to 1025° F.) where brittleness occurs with considerable speed, clearly shown by the curves in Fig. 1.

The tempering time T_1 and temperature t_1 , which often alter the value of S considerably, have little influence on the critical speed V_c . On the other hand, different steels of the same chemical composition as regards amount of alloy but submitted to different working and fabricating operations will have the same susceptibility, S , and far different values of the critical speed (Fig. 2). As to quenching phenomena, that is, the possible variations in the temperature of transformation of austenite, noted as Ar' , Ar'' , and Ar''' , they seem to have no relation to this type of brittleness in a given steel.

Two unpublished results, however, appear to be most important, as follows:

1. The two characteristics S and V_c may vary in the same steel depending on the orientation of the test piece to the direction of rolling or maximum elongation during hot work, and

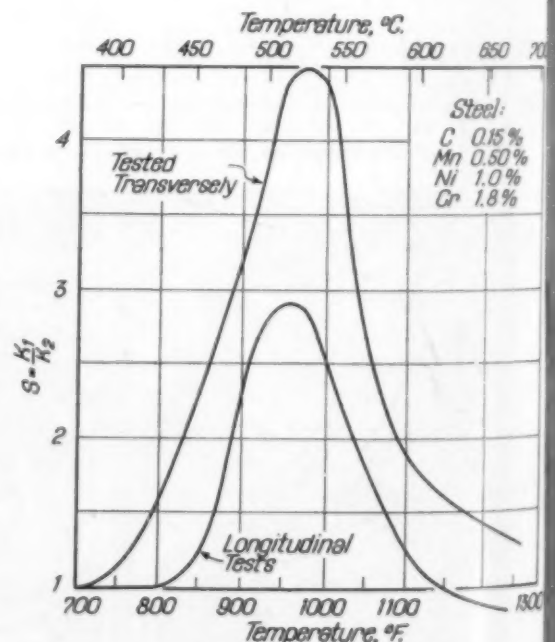


Fig. 1 — Variability of Intensity of Temper Brittleness in a Certain Steel When Held for a Given Time at Various Temperatures

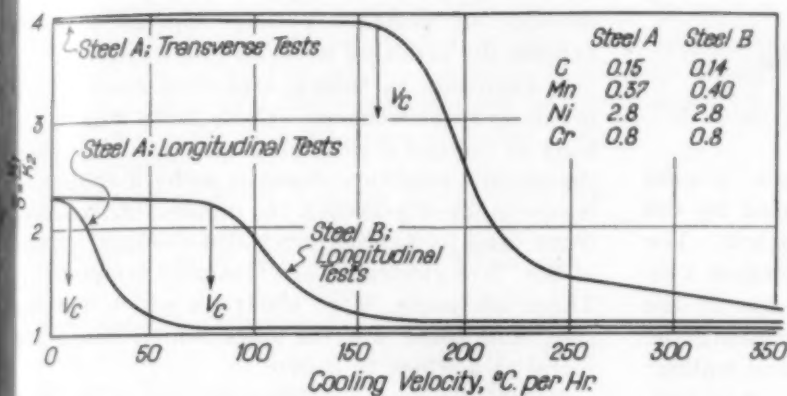


Fig. 2 — Variability in Cooling Speeds Necessary to Suppress Temper Brittleness in Two Nickel-Chromium Steels

can vary considerably in the transverse and longitudinal directions (Steel A in Fig. 2). Best ductility therefore requires an optimum reduction of the metal in working for the desired combination of longitudinal and transverse toughness, and thus the influence of the final treatment which can either reduce or considerably exaggerate the transverse brittleness.

2. More complete tempering by prolonging the holding time T_1 or raising the temperature t_1 , which tends to coalesce the microconstituents, reduce and even entirely suppress the temper brittleness. For example, the nickel-chromium steel of Fig. 1 may have $S = 4.6$ when tempered for 15 min. at a given temperature; S falls to 3.8 when the time is increased to 30 min., 2.7 at 1 hr. and approaches 1.0 when tempered 16 hr. On the other hand, if 30 min. be judged to be the maximum time permissible, S may drop from 3.8 to 1.3 by increasing the temperature 70°C . (125°F .).

These results indicate that temper brittleness is the manifestation of a variable solubility in alpha iron of a constituent or phase which forms at the time of tempering, and which later separates during slow cooling or during holding at a lower temperature t_2 . This embrittling precipitate probably accumulates in the crystalline planes of the ferrite.

If the phase formed on tempering is disperse, much of it will be in solution at the tempering temperature, with later intra-granular re-precipitation causing brittleness. If the initial phase is coalesced, there will be only a slight amount in solution around the surface of the particles, and re-precipitation will probably occur on the particles and will not induce brittleness.

Temper brittleness is not a phenomenon which occurs only in certain steels considered "sensitive" or "susceptible". In principle it is

always present, but in certain cases the S ratio is very slight, or the speed V_c is beyond the experimental and practical limits, so it cannot be observed in practice. On the other hand, when it does occur it can be reduced or suppressed entirely by:

1. Decreasing the holding time in the critical range for occurrence of this brittleness with rapid subsequent cooling after tempering.
2. Coalescing the preliminary dispersion, by proper adjustment of the tempering temperature and time.

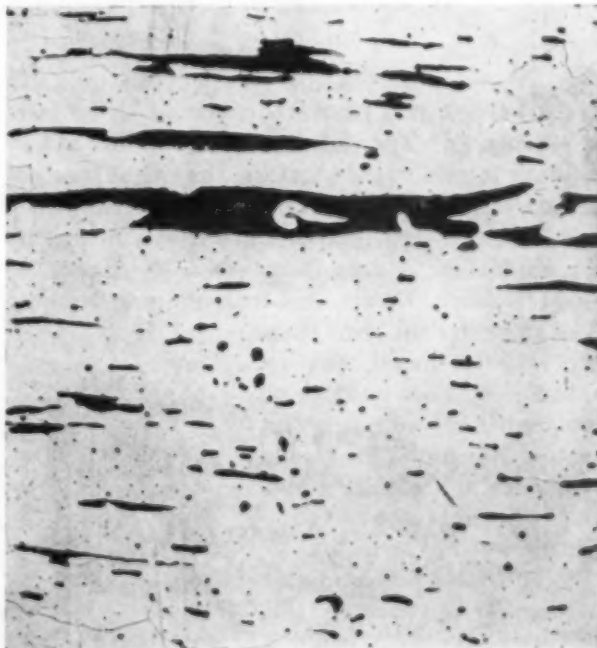
ALBERT PORTEVIN
Bessemer Medalist

A Civil War Ghost

JAMESTOWN, N. Y.

To the Readers of METAL PROGRESS:

A piece of wrought iron, alleged to have been cut from the armor plate of the Confederate ram "Merrimac", was brought into our laboratory.



Inspection revealed an interrogation point in the slag. Does this really mean that the piece is not the genuine article?

STEPHEN HUIJBER, JR.
Metallographer
Marlin-Rockwell Corp.

Brass Welds, Made by Detonation Impulse

BUFFALO, N. Y.

To the Readers of METAL PROGRESS:

The adjoining micrographs show a weld between two thin brass disks produced by the detonation impulse in the set-up sketched. The disks were of half-hard brass approximately 1 in. diameter by 0.035 in. thick. All parts in the set-up were held securely by tightening the threads of the seamless tubing at top and bottom; the detonator was the only part not securely held.

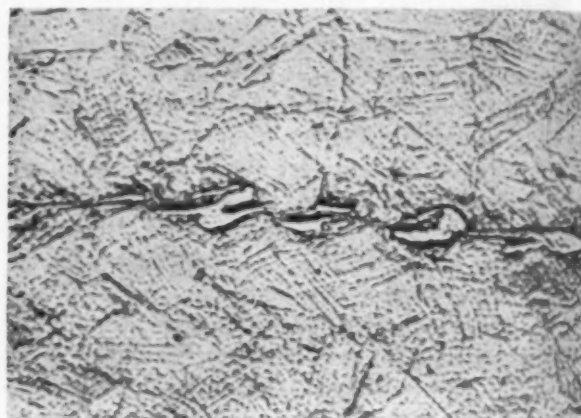
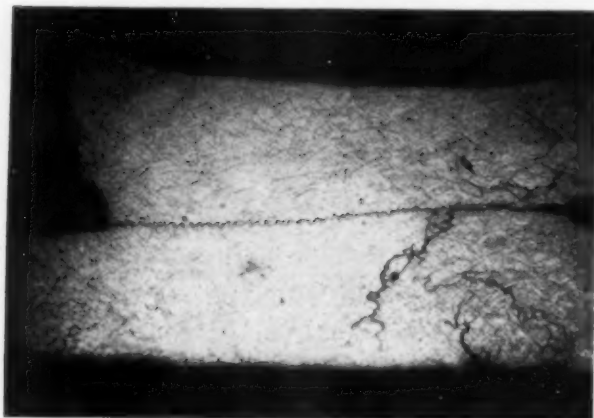


Fig. 1 and 2—Section Through Disks of Half-Hard Brass. Welded During Test of Explosive, at 100 and 250 Diameters Respectively

The specimen was recovered during routine tests of explosives. The object of the test was not to produce a weld and, therefore, the metal was not prepared in any way to facilitate that result.

It would seem that the metal was heated by the explosion to a temperature high enough to cause welding. Were this true, the metal would be softer after the weld than the original metal, due to subsequent slow cooling of the half-hard sheet. The fact is the metal fragment is somewhat harder than the original—probably caused by cold working.

The opinion is held that detonation is transmitted by an extremely sudden impulse which produces a pressure increase as sudden as that produced by ultrasonic waves. (See *Journal of the Franklin Institute* for June, 1943, page 553.) Such a sudden increase and

the electrical resistance of most metals decreases when the pressure is increased. Increased pressure, then, causes a larger proportion of the electrons to exist in the free state. Now then, if two pieces of metal were held firmly together and subjected to extremely sudden pressure changes the number of free electrons would very suddenly

increase and decrease. As we have seen, the coherence of the metal is due to the electrons which are not free. When the number of free electrons suddenly decreases or becomes fixed, it is conceivable that they might be in such a position as to cause adhesion between two pieces of metal as well as to remain entirely within the original metal.

The photomicrograph at higher magnification shows the weld interrupted by voids or inclusions. This interrupted weld is believed

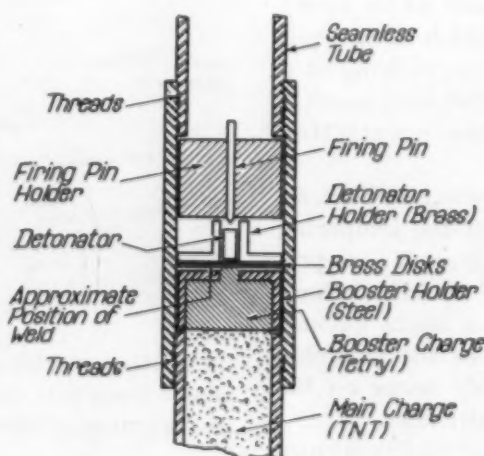


Fig. 3—Cross Section of Set-Up for Testing Explosive

to be due to the fact that the sudden impulse caused one disk to slip over the other, and in this way the impurities on the metal surfaces were segregated and the weld occurred at the points where the surface impurities had been rubbed away.

Bergmann, in his book on "Ultrasonics and Their Scientific and Technical Applications", has discussed some of the effects of ultrasonics on metals. He says: "Hollmann and Bauch were able to show that ultrasonics produced in a nickel rod a loosening of the molecular magnets, whereby the process of reversal of magnetization is considerably facilitated. We are, therefore, dealing here with a loosening in the crystalline structure of ferromagnetic material by high frequency sound waves...."

"The rate of diffusion of nitrogen into steel is very small at the temperatures commonly used. This depth of penetration is considerably increased, according to Mahaux and Guillet, under the action of high-frequency sound waves, and penetration also takes place more quickly."

It seems to the writer that it would be worth while to investigate metals which have been especially prepared to facilitate welding with explosive charges, and also with ultrasonic waves of known frequencies, to determine the exact conditions under which the various metals would join together.

LEROY R. CARL

Farewell to Metallurgy

KNOXVILLE, TENN.

To the Readers of METAL PROGRESS:

You may be interested in a photograph of something I found on the blackboard the morning of my final class for Army Specialized Training Program students. They had recently been ordered back to combat service, and despite their



general disappointment in being yanked out of engineering school, could still see the funny side of things. Latrine rumor has it that the cartoonist was Pfc. William Wei Lee.

DAVID J. MACK

Asst. Prof. of Chemical Engineering
University of Tennessee

Order-Disorder in Micro-Photo Compounds

WORCESTER, MASS.

To the Readers of METAL PROGRESS:

In a recent letter published in March, Elsie L. Garvin has pointed out that the newly developed technique of studying the microstructure of metals by radiography is misnamed when it is called *microradiography*, just as it is now generally accepted by metallurgists that *microphotography* should not be used when *photomicrography* is meant. By analogy with the latter, the correct word for the new technique would be *radiomicrography*, and not *macroradiography* at all, as proposed by Miss Garvin on the erroneous assumption that low magnifications are involved. As a matter of fact, a magnification of 100 diameters is commonly used in radiomicrography so that *micro* and not *macro* is the correct word element. Furthermore, the word *macroradiography* is just as wrong from the standpoint of the order of the word elements as is *microphotography* when *photomicrography* is meant, at least if any rules are to be observed as to the manner of building up such words. It should be kept in mind that in all these cases the generic words are *micrography* and *macrography* and it is to these that the prefixes should be attached.

L. P. TARASOV

Research Laboratories
Norton Company

WATERBURY, CONN.

To the Readers of METAL PROGRESS:

Elsie Garvin's comment seems to have overlooked the fact that, in English at least, the terms which have been accepted through common usage may not at first glance appear the most logical for the purpose. A typical example of such illogical usage is contained in her own discussion where the word "photomicrograph" implies considerable enlargement whereas the word "macrophotograph" implies only a minor degree of enlargement. (Why not photomacrograph?)

In coining or compounding a new word it is necessary to consider the euphony of the structure as well as its logical meaning deduced from

the etymology of associated word types. Inspection of Webster's New International Dictionary (Unabridged) shows, among others, the following examples where the prefix "micro-" implies the recording, on a visible scale, of measurements made of minute quantities: Microanalysis, micro-method, micromotoscope, micronometer, micro-phonograph, micropolariscope. By contrast, we have the following words implying a minute record of relatively gross things: Micropantograph, microphotography. Examining associated words from another direction we find the following relationships: spectroscopy—spectrography; radioscopy—radiography; microscopy—micrography. In all of these cases the suffix "-graph" indicates a graphic reproduction or recording of the entities concerned. When photography is used as the recording method it is only in the last

case that it is felt necessary to introduce the prefix "photo-" to make clear just how the record was produced.

In the case of microradiography the suggested word "macroradiography" might well be substituted in, say, investigations on spot welds where the magnification has usually been of the order of about 10 diameters or less. This would conform in meaning with the word "macrophotograph". However, for techniques involving the magnification of a radiograph by larger amounts, such as 100 diameters or more, the prefix "macro-" is no longer applicable, whereas the prefix "micro-" is quite satisfactory from the etymological standpoint.

From standard usage in applying prefixes, the word "microradiography" also indicates that the radiograph occurs first and the "micro" procedure occurs later. Any such transposition of syllables as "radiomicrograph" would not have this connotation.

In short, while one might conceive of a substitute such as "magniradiography", the present use of the word microradiography seems significantly well fitted to describe this new metallurgical technique.

S. E. MADDIGAN
Research Physicist
Chase Brass & Copper Co.

[EDITOR'S CLOSURE—Let's try—note the modest use of the word *try*—to use "photograph" and "radiograph" in the pages of *Metal Progress* to mean reproductions at ordinary degrees of enlargement or reduction, and in sentences where there is no need of distinguishing between "macro" and "micro". Let's say "micrograph" when we intend to convey the idea that the object is magnified considerably in reproduction (and for this word, "micro" will be an acceptable slang replacement, at least in *Metal Progress*). If it is necessary to distinguish the method of registry we can say "photomicrograph" or "radiomicrograph". Finally let's use the words "photomacrograph" and "radiomacrograph" sparingly, when we must denote intermediate enlargements.]



Welded, All-Metal Life Raft, Built by Weber Show Case Co. of Los Angeles for Maritime Commission. Its compartments are filled with a half-ton of supplies for 20 men, ranging from tarpaulin, flares and oars to medicine and fishing tackle. Some life-saving problems still await solution, however, such as: 1. Means for removing salt from sea water by ionic exchange; 2. Life vest that automatically inflates and turns unconscious man right side up; 3. Methods of inflating rubber boats quickly with CO₂ at sub-zero temperature

Metallurgicus's

Own Page

Emergency Tempering Equipment

AN EMERGENCY in our tool department, caused by a shortage in tempering equipment and a demand that the tools be given an extra long tempering cycle, was met by two dodges, each of which proved to be successful in results.

1. The tools were brought to the desired temperature for tempering in the usual manner and left in the furnace as long as the production schedule would allow. Since the permissible time was short of the desired time by some hour or hour and a half, the tools were then carefully packed in powdered asbestos which allowed the tools to cool slowly to room temperature. The machine shop reported no change in performance of these tools over tools given the long draw.

2. A discarded electric stove was set up in the hardening department. The oven regulator was checked for correct registration and a fan installed for circulating the air. This "furnace" also worked out very successfully as a tempering medium. (PHILIP F. ATWOOD, East Orange, N. J.)

Soft Soldering on Zinc Plated Parts

JOINING of zinc plated parts by soft soldering is difficult with ordinary fluxes. Because of the "greasy" nature of the zinc, solutions of fluxing salts usually do not cling. A small amount of a suitable wetting agent, added to the flux solution, causes this liquid to remain where it comes in contact with the plating. We have found that "Tergitol" supplied by Carbide and Carbon Chemicals Corp. or "sulphatate" supplied by the Glyco Products Co. is satisfactory.

Another important requirement for good soldering is to cause the moisture to evaporate

and the flux to melt on the work in advance of the flowing solder. Zinc chloride melts at 482° F., whereas solder begins to melt at 361° F. It is, therefore, desirable to use a flux having a lower melting point than that of zinc chloride, such as a eutectic mixture of zinc chloride and ammonium chloride, which melts at about 375° F. For this reason a flux solution containing 355 g. of zinc chloride, 145 g. of ammonium chloride, and 5 ml. of "Tergitol 08" in 1000 ml. of water is excellent for soldering on zinc. This flux may be applied by dipping or brushing. If any flux remains on the parts after soldering, it readily washes off in water.

When open flames are used for heating the parts to be soldered, care must be taken not to destroy the zinc coating, which melts at 787° F. A handy method for checking the temperature of the work is to use "Tempilsticks" supplied by the Tempil Corp. (H. L. CAMPBELL, Chief Metallurgist, McInerney Spring & Wire Co.)

Rotate During Electro-Polishing

ELECTRO-POLISHING of aluminum and copper micro-specimens has proven very successful when the specimen is rotated and the following technique used:

Aluminum — For aluminum the usual electrolyte is employed, two parts of 60% perchloric acid added *very carefully* to seven parts of acetic anhydride. A portion of this master solution is taken for use, about 5% water being added. During the life of a batch of electrolyte it is important to avoid diluting it further, as by using wet beakers. A cylindrical glass dish 4 in. in diameter is filled with the working solution to a depth of 1 1/4 in., and aluminum strip on the bottom of the dish serves as a cathode. (A satisfactory area is 5 sq.in. of 0.03-in. gage.) An ice bath is used to keep the solution cold during the operation. The specimen, a 3/4-in. cylinder about 1/2 in. long, is suspended by a clamp above the surface of the

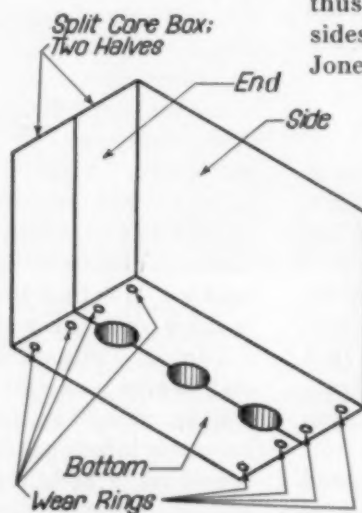
bath, only the face to be polished being submerged. Previously the specimen has been polished through 3/0 metallographic paper, and then on the first broadcloth lap using alumina. The clamp holding the specimen is attached to the bent shaft of an air-motor; thus during rotation the specimen is caused to describe small circles in the surface of the electrolyte. In order to prevent the formation of ridges on the polished surface the rod holding the specimen is turned 90° about its axis every 30 sec. Polishing for 5 min. at 50 to 70 volts and 1.5 amperes produces an excellent polish.

Copper—The electrolyte for copper is 85% orthophosphoric acid diluted with one part of water. The distance from the specimen to the copper cathode is about ½ in., but otherwise the mechanical details are the same as for aluminum. Using a ½-in. square specimen a polishing time of 1 or 2 min. at 2.5 volts and 0.5 ampere produces a satisfactory surface. (ALBERT GUY, Instructor in Metallurgy, Carnegie Institute of Technology)

Armored Nibs on Core Boxes

AN OHIO FOUNDRY has solved a maintenance problem in its core room by using fish-line guide rings of cemented carbide—quite a popular peacetime application of a material that withstands perfectly the cutting action of fast-running silk or wire fish-line. The core boxes, of aluminum, are open top and bottom, are split and the halves are lined-up with dowel pins. In use, the box is filled with rammed sand, and the box is rubbed over the bench top to smooth off the bottom.

This rubbing over the bench top covered with highly abrasive core sand wore away the bottom of the boxes unevenly, and put such a strain on the dowel pins that in time the box had to be scrapped or overhauled, the life of the average aluminum core box being only about 1500 cores. Eight of the small carbide rings let into the bottom of each box, as shown in the sketch, cured the trouble, lengthening the service life of the core box at least six-fold. (S. H. HORN, Sales Engineer, Carboly Co., Inc.)



Preventing Scale From Affecting Hardenability Tests

VARIOUS METHODS are used to protect the end and sides of the Jominy bar from scaling during heating before the quench, such as (a) a furnace with neutral atmosphere, (b) standing up in a deep layer of cast iron chips, (c) standing in holes drilled in a block of steel or cast iron, (d) standing in a closely fitting stainless steel cup, (e) copper electroplating.

We believe the latter is most effective, for it prevents carburization, decarburization and oxidation. A simple substitute seems to combine the advantages of copper plating with ease of application. This method consists of dipping the specimen, for about an inch of the water-cooled end, into a solution of blue vitriol (cupric sulphate 500 g., sulphuric acid 120 ml., water 3000 ml.).

The specimen must first be cleaned in 10% sodium hydroxide or some similar alkali bath before dipping, to make sure that it is clean, and free from all oil or grease. It is then dipped into the copper solution for about 30 sec., removed, washed, and again placed in the solution, and allowed to remain there for about 2 min. This results in a more permanent type of coating than is obtained from a single dip. The thickness of the copper coating depends upon the length of time that the specimen remains in the solution, but heavy coatings of copper tend to crack and chip off the specimen too easily.

This thin layer of copper does not entirely eliminate the formation of scale, but it does make a type of scale which is brittle, and does not tend to adhere to the steel. In many cases the scale chips from the specimen as soon as the column of water strikes the water quenched end, and thus there is no chance for water to creep up the sides of the bar. (R. G. TOWNSEND, Chief Chemist, Jones & Lamson Machine Co.)

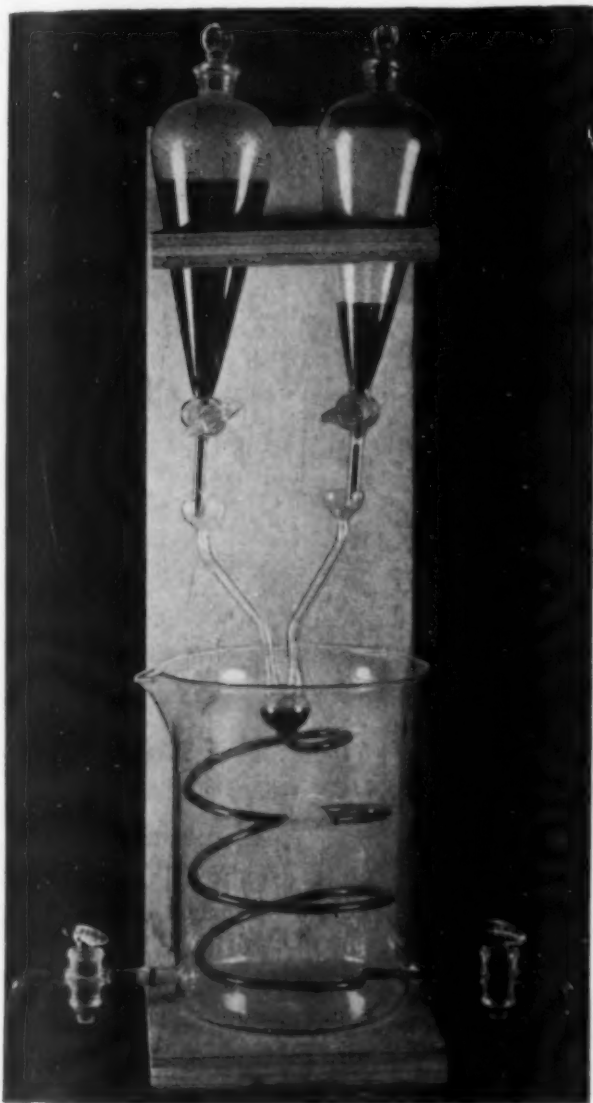
Mixing Electrolytic Polishing Solution

IN POLISHING electrolytically one of the chief solutions used as an electrolyte is a mixture of perchloric acid, acetic anhydride, and water. However, this has the disadvantage of being difficult to mix since the reaction is exothermic and the solution must be under 85° F.

The accompanying picture shows an apparatus designed at the Naval Research Laboratory for mixing it with

greater safety and less time, the idea being that it is safer and quicker to bring the components together in their proper ratio than to drip the acetic anhydride into the perchloric acid.

The flow of the solution is adjusted at the required ratio of $4\frac{1}{4}$ to 1 by stop-cocks on the 250 ml. separatory funnels. The two components



are mixed in the small spherical shaped reaction chamber and the cooling coil, both of which are kept cool by crushed ice. The solution is run into a container which is also kept cool by crushed ice. It is interesting to note that the temperature of the solution as it leaves the cooling coil is only 40°F . The small amount of water in the solution is added to the second container by a burette. The melted ice is tapped from the beaker by a stop-cock.

In order to construct the apparatus as shown, considerable skill is required. If a glass tech-

nician is not available, a similar apparatus could be made along the same principle from spare glass or metal parts. However, the one fact that one must bear in mind is that the solution may not come in contact with any organic material.

It has been found that this apparatus has accomplished the dual purpose of being safer and reducing the mixing time from eight hours to two hours. (JACK H. GOODYEAR, Naval Research Laboratory)

Testing Continuity of Chromium Flash

SOME of our manufacturing operations require a chromium flash or thin plate over flat steel parts, and we have developed the following satisfactory test for continuity. The tested part must be replated; likewise only one test can be made on it, as the plate may be only 0.0005 to 0.00075 in. thick.

A simple electrograph may be used consisting of:

- (a) Four No. 6 dry cells.
- (b) Two small battery clips.
- (c) One flat piece of carbon or graphite having sufficient area to accommodate the surface of specimen.
- (d) Insulated flexible wire for making connections.

Connect the four dry cells in series and fix suitable lengths of insulated wire to the positive and negative terminals. Attach the battery clips on the ends of each lead. The flat piece of carbon or graphite is made the negative electrode and the test specimen the positive electrode. Completion of the circuit is accomplished by moistened filter paper placed between the carbon and the test specimen.

Procedure is as follows: Immerse a filter paper of sufficient size to cover the area being tested into a solution of 5 g. potassium thiocyanate in 10 ml. distilled water. Remove immediately and allow to dry for 3 to 5 min. Insert filter paper between specimen and carbon or graphite surface and contact the specimen momentarily (approximately 1 sec.) with the paper. Remove the paper and observe. If a continuous chromium flash or plate is present no color will develop. If the flash or plate is irregular, a red coloration will appear wherever bare steel is exposed, and if no chromium plate is present a deep red color will be developed over the entire surface of the paper contacted by the part. It is very important that only a momentary contact be made when checking a chromium flash. (C. H. ANESHANSLEY, Materials Laboratory, National Cash Register Co.)

Macroscopic Etch for Weld Sections

A SIMPLIFIED METHOD of etching weld sections in carbon and low alloy steel, prior to macroscopic examination, consists of immersing the specimen for 30 to 60 sec. in a solution of 0.5 to 1% nitric acid in water. The etching time increases as the strength of the solution decreases, and this may be varied as the operator desires.

Methods commonly used for this type of etching are:

1. Swabbing with a saturated solution of ammonium persulphate for a few seconds.
2. Swabbing with 2 to 5% nital solution.
3. Immersing in 2 to 5% nital solution.

The advantages of the new method are:

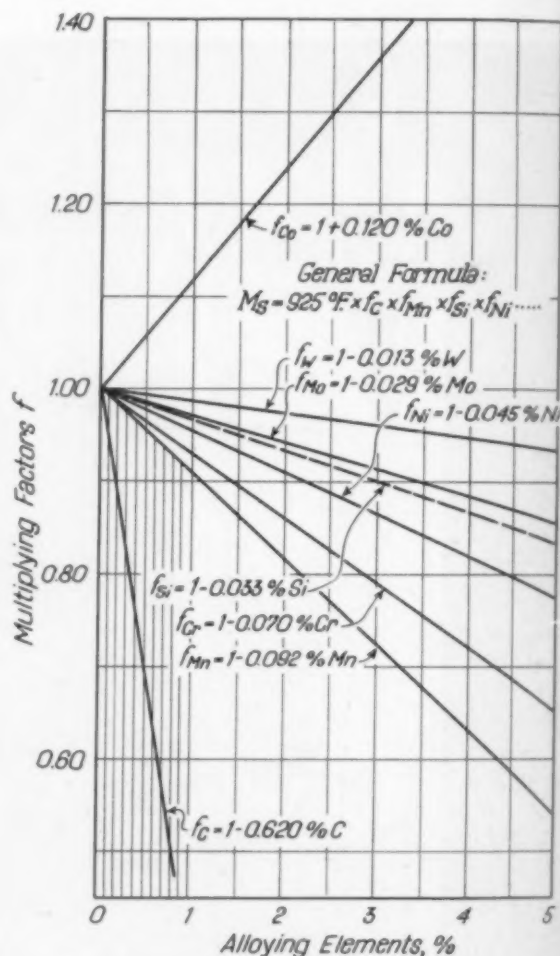
1. The etched surface is not stained by pieces of cotton or lint which tend to catch when swab etching.
2. Greater uniformity and better control are obtainable during the longer etching period.
3. Surfaces on several different planes may be etched simultaneously without the possibility of staining.
4. The ingredients of this etch — water and nitric acid — are easily obtainable and inexpensive. Even tap water can be used.

The specimen is prepared by grinding on 80 and 240 grit emery belts. The surfaces to be etched are cleaned with soap and water, dried, and wiped with a clean rag soaked with alcohol or carbon tetrachloride. (It is essential that the surfaces be free from grease and dirt to obtain a uniform etch.) The etchant is mixed in any acid resistant container of suitable size; a glass beaker allows the observation of almost all surfaces as they are etching. Upon removal from the etchant, the specimen is plunged into a container into which a continuous supply of hot water is running. After thoroughly rinsing, it is dried by an air blast. (PHILIP R. SPERRY, Metallurgist, Glenn L. Martin Co.)

Computing A'' or Ms (Transformation Temperature on Quenching) From Analysis

THE ATTACHED GRAPH will be useful in computing the temperature where martensite starts to form in a rapidly cooled piece of steel. This temperature is noted as the A'' point in the older writings on delayed transformation; Shepherd in recent articles about "martempering" dubs it the Ms point. Greninger, Chiswick, Payson and Savage have shown how the various elements influ-

ence it, and their data are plotted as judiciously as possible in the graph. The method was first submitted as a discussion to the Payson and Savage paper in *Transactions* for 1944, page 277, but unfortunately the diagram was in error. Those who save *Transactions* rather than *Metal*



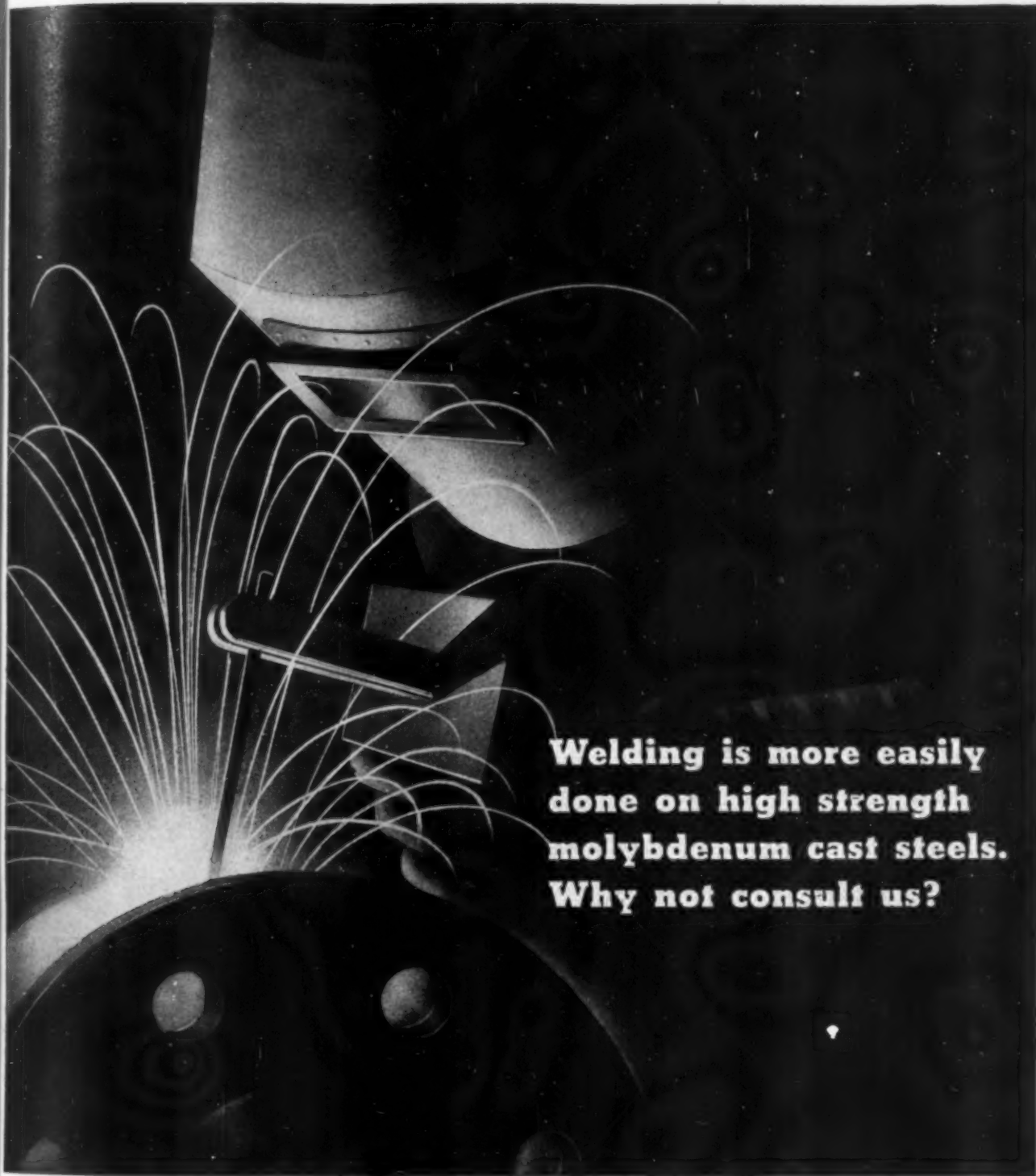
Multiplying Factors and General Formula for Calculating Ms or A'' Point of Steel

Progress may wish to cut this out and paste it over the incorrect one.

We have found the curves useful in our work. The Ms temperature can be computed, or the various factors scaled from the graph. An example follows:

ELEMENT	%	f
C	0.61	0.622
Mn	0.50	0.954
Si	0.24	0.992
Ni	0.16	0.993
Cr	0.94	0.934
Mo	0.33	0.990

Calculated value comes out to 500° F., which checks the observed value. (LOUIS A. CARAPPELLA, Industrial Fellow, Mellon Institute of Industrial Research)



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Personals

J. EDWARD DONNELLAN has resigned his 20-year post with the ☉ to become vice-president in charge of sales for General Alloys Co., the organization of our good friend, HARRY HARRIS. He will move to Boston, which does not displease Ed and Edith, both Yankees. He will leave behind a gaping hole in

the Society's organization that will be most difficult to fill. His work in Cleveland is marked with a lasting monument, for the ☉ Metals Handbook under his fostering care has grown from a few Lefax sheets into an encyclopaedic reference book of international authority. They take with them our affectionate good wishes.

E. E. T.

Honored by the American Foundrymen's Association: RUFUS F. HARRINGTON ☉, foundry superin-

tendent, Hunt-Spiller Mfg. Co., awarded the John A. Penton Gold Medal for outstanding pioneering work in foundry sand control; STANLEY W. BRINSON, master molder, Norfolk Navy Yard, presented an honorary life membership in the Association; CARL F. JOSEPH ☉, research metallurgist, Saginaw Malleable Iron Division, General Motors Corp., the William H. McFadden Gold Medal for outstanding metallurgical and shop practice contributions to the foundry industry, especially the malleable iron section.

Cited by the Office of the Chief of Ordnance for outstanding personal achievements in producing steel cartridge cases: FRED M. ANOLD ☉, HARRY F. EHRLICH and JOHN A. KINGSTON of the Norris Stamping and Mfg. Co., Los Angeles, and HARLAN A. MESSNER ☉ of the Ohio Crankshaft Co., Cleveland.

OTTO W. WINTER ☉ has been appointed vice-president of the Acme Pattern and Machine Co. of Buffalo, N. Y.

ROBERT S. WESTWATER ☉ has resigned as metallurgical engineer with North American Aviation of Kansas to join the Naval Reserve, and is attending the Naval Academy at Annapolis.

J. C. SCHONHARDT ☉, formerly metallurgist, Curtiss-Wright Corp., Louisville Plant, is now district manager for Jessop Steel Co. in the St. Louis office.

EMANUEL GORDON ☉, formerly metallurgist for Carnegie-Illinois Steel Corp., McKeesport, Pa., is now employed as metallurgist at Massachusetts Institute of Technology.

JOHN W. WILEY, SR., is now employed at the Nutmeg Heat Treating Co., Bridgeport, Conn.

GEORGE L. TIER, JR. ☉, formerly with Aluminum Co. of America Research Laboratory, New Kensington, Pa., has joined the U. S. Navy and is stationed at Great Lakes, Ill., assigned to the Radar Division.

H. J. ELMENDORF ☉, formerly research engineer in Cleveland for American Steel & Wire Co., has been transferred to the company's plant in Worcester as metallurgical spring engineer.

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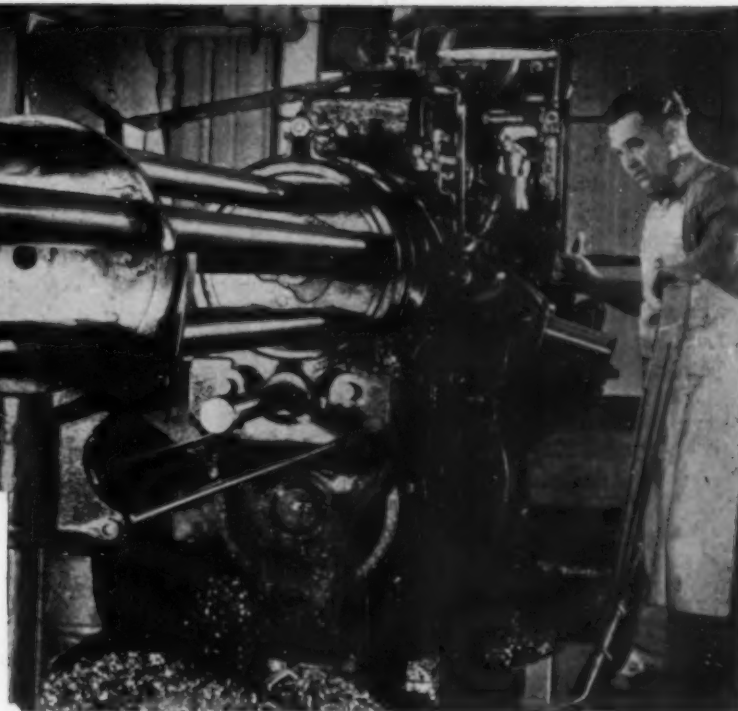
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Revere doesn't pretend to supply all the answers immediately, but if it is humanly possible to better your experience, we will be glad to help. It is always a pleasure to dig into difficulties and cooperate with you in reducing them, if not eliminating them entirely. This help is given freely, without obligation, of course. All you need do is ask.

• • •

There is much helpful information in "Revere Copper and Copper Alloys—Technical Information for Product Designers." This manual has 54 pages, 106 graphs relating to the physical and metallographic properties of these alloys under varying conditions, a new chemical and physical properties chart, and valuable illustrated data on welding. Ask for your complimentary copy.

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Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere mill products — sheet, strip, rod, bar, pipe, tube — are stocked by leading metal distributors.

Personals

COMDR. H. O. DAHLKE ☉ has reported for duty at Charleston Navy Yard as machinery and repair superintendent.

H. C. MILLER ☉ has resigned as vice-president, Springfield Heat Treating Corp., to become plant metallurgist for the American Bosch Corp., Springfield, Mass.

COL. G. F. JENKS ☉, U. S. Army retired, formerly associated with Taylor-Winfield Corp., has accepted a position with North American Aviation, Inglewood, Calif., in the office of quality control.

PAUL T. KEEBLER ☉ has been appointed plant manager of the industrial car division of the Phillips Mine and Mill Supply Co., Pittsburgh, succeeding R. R. PHILLIPS ☉, who recently joined the Armed Forces as lieutenant (j. g.) in the U. S. Navy.

Promoted from major to lieutenant colonel: PAUL C. CUNNICK, chairman Tri-City Chapter ☉, in charge of metallurgical laboratories, Rock Island Arsenal.

DONALD E. RODA ☉, formerly with the Rochester Products Division of General Motors Corp., Rochester, N. Y., is now chief metallurgist and head of the process engineering department, Pacific Division, Bendix Aviation Corp., North Hollywood, Calif.

ROBERT B. SOSMAN ☉ and JAMES B. AUSTIN ☉ have been appointed assistant directors of U. S. Steel Corp. Research Laboratories, Kearny, N. J. ROBERT H. ABORN ☉ has been appointed supervisor of physical metallurgy.

HARRY D. CHURCHILL ☉, associate professor of mechanics, Case School of Applied Science, Cleveland, has been promoted to full professor.

N. B. LANTZ ☉, formerly industrial gas engineer with the Public Service Co. of Indiana, has been appointed manager, standard equipment division, Dempsey Industrial Furnace Corp., Springfield, Mass.

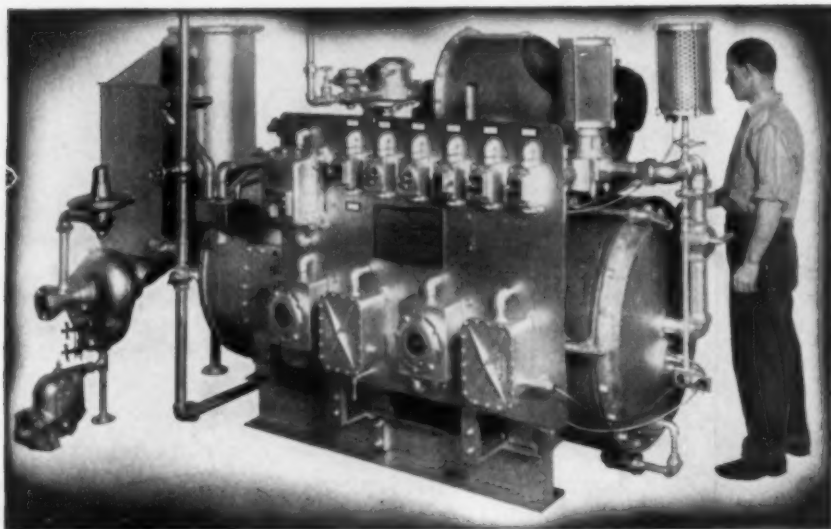
DONALD B. WILLIAMS ☉, formerly metallurgist at the Duquesne Works of Carnegie-Illinois Steel Corp., has been appointed assistant chief metallurgist, Duquesne Smelting Corp., Pittsburgh.

W. E. REMMERS, past chairman, Chicago Chapter ☉, has been elected vice-president of Electro Metallurgical Sales Corp., New York.

L. F. GRAVES ☉ has been promoted from heat treat and X-ray foreman at LaPorte Works, Allis Chalmers Mfg. Co., to works metallurgist.

A. E. RHOADS ☉, formerly manager of the Detroit Electric Furnace Division of Kuhlman Electric Co., has been elected executive vice-president and general manager of the Kuhlman Electric Co., Bay City, Mich.

CLINTON E. SWIFT ☉, formerly manager of the welding division of Ampco Metal, Inc., is now assistant manager of the engineering and research department of Eutectic Welding Alloys Co.



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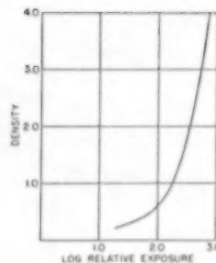
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Personals

ALBERT R. FAIRCHILD ☉, formerly in charge of the heat treatment department at New York Shipbuilding Corp., is now metallurgist with the Troy Heat Treating Co., Troy, N. Y.

O. L. PREBLE, JR. ☉ is now resident field engineer in the New York metropolitan area for Philco Corp.

JEROLD L. WELCH ☉, formerly with Fedder Mfg. Co., Buffalo, N. Y. as chief inspector, and Sterling Engine Co., Buffalo, as manager of Syracuse Subcontract Office, is now products engineer for Superior Foundry Co., Cleveland.

JAMES H. NANGLE ☉, formerly with Pratt & Whitney Division, United Aircraft, East Hartford, Conn., is now metallurgical consultant, Foster Dee Snell, consulting chemists and engineers, Brooklyn, New York.

Elected to the board of trustees of Battelle Memorial Institute Columbus, Ohio: ZAY JEFFRIES, past president ☉, technical director lamp department, General Electric Co., Cleveland, chairman of Carboloy Co., Inc., and vice-chairman of the War Metallurgy Committee.

M. D. BENSLEY ☉, formerly assistant to the president, Shenango Penn Mold Co., has been appointed general manager of the three plants of H. K. Porter Co., Inc., Pittsburgh—namely, Mt. Vernon Car Mfg. Co., Wheel Foundry Division of Mt. Vernon Car, and J. P. Devine Mfg. Co.

FLOYD J. DE VAN ☉ and HENRY A. BISCHOFF have formed the Hy-Alloy Steel Co., Chicago, to carry on the distribution of alloy steel bars from mill and warehouse stocks.

F. L. MACNAMARA ☉, formerly superintendent, zinc division, Ball Bros. Co., Muncie Ind., is now manager, can division, Ray-O-Vac Co., Fond du Lac, Wis.

E. QVARNSTROM ☉ is now heat treating engineer with the tool engineering department of Grumman Aircraft Engineering Corp., Bethpage, Long Island, N. Y.

JOHN F. CRUM, JR. ☉ has resigned as plant metallurgist of plant No. 3, Bohn Aluminum and Brass Corp., to enter the Navy in the near future.

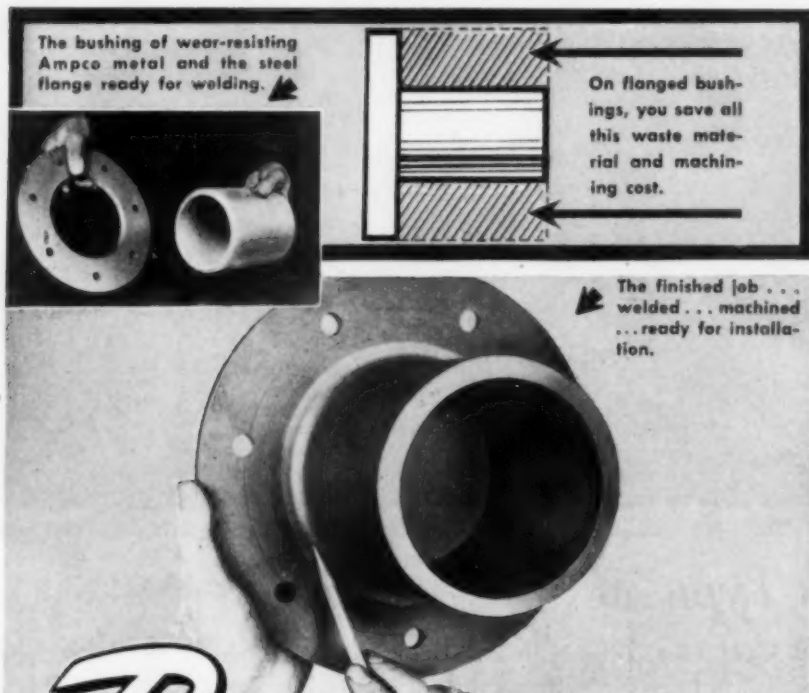
W. A. DYE ☉, formerly melting superintendent at Copperweld Steel Corp., is now in the melting department of the Universal-Cyclops Steel Co., Bridgeville, Pa.

Promoted by Standard Steel Works Division of Baldwin Locomotive Works: JOHN D. TYSON ☉ from manager of sales and metallurgy to divisional vice-president.

DAVID F. CARTER ☉, formerly metallurgist at Firestone Tire & Rubber Co. of Tennessee, is now a metallurgist for Republic Steel Corp. in Chicago.

ALEX RUBIN ☉ is now assistant metallurgist at the Norfolk Navy Yard.

WILLIAM A. WHITESIDE has been elected secretary of the Quaker Chemical Products Corp. of Conshohocken, Pa.



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If you are one of those who are waiting, we'd like you to know that we will do everything in our power to minimize your delay.



BELL TELEPHONE SYSTEM

Inspection in a Manufacturing Plant*

By D. B. Keeling and L. E. Cisne

THE "Average Outgoing Quality Limit" double sampling plan involves the examination, on a "go no-go" basis, of a specified number of articles taken at random from a large group. The acceptance or rejection of this

entire group is usually made on the basis of results obtained from the first sample alone. However, if the results from the first sample are not conclusive, an additional sample is examined. Just how large the sample lot should

be is shown in statistically determined tables of lot sizes and corresponding sample sizes. Double sampling may be applied to the output of any unit operation capable of sufficient uniformity

Analysis of Process

To determine the applicability of this plan it is necessary to examine the manufacturing and inspection processes and all data available regarding past quality performance, such as records of per cent defective, consumers complaints, and so on.

The lot of articles to be examined should consist of product which is available in its entirety for acceptance or rejection at one time. For sampling purposes, the lot should consist of articles made from uniform raw material by operators of equivalent skill and by machines or methods of equivalent precision.

Lots should be as large as the limitation of uniformity will allow. In sampling from larger lots it becomes increasingly important that each sample should be a group of articles taken at random from different locations throughout the lot so that it will represent an impartial cross-section.

There must, of course, be a known standard of acceptability for the individual article.

Close cooperation between production and inspection personnel is required in assuring that rejected lots are thoroughly cleared of all defectives.

Double Sampling Table

Tables are constructed by the director for a variety of "Average Outgoing Quality Limit" (AOQL) values and "Process Average" (PA) classes. The AOQL value is the maximum value of average per cent defective in the product after inspection, (Cont. on p. 118)

*Abstracted from *The Bell System Technical Journal*, June 1942, page 37.

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SENTRY MODEL "Y"
High Speed Steel Hardening Furnace

The demand for Sentry Model "Y" Diamond Block Furnaces is now greater than ever before.

WHY?

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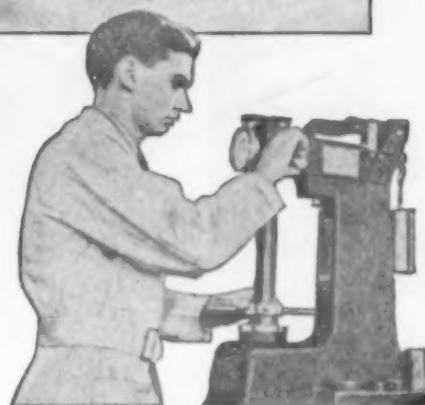
WRITE FOR BULLETIN 1024-1A



The Sentry Company
FOXBORO, MASS., U. S. A.



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To Look for
in Resistance Welding Electrodes
is Something You Cannot See...*



Quality Control . . . for the Right Alloy, Correctly Produced

Prescribing the proper electrode alloy for a specific welding job is important. Even more important is the ability to make that alloy so that its composition never varies in process of production.

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roll or die. It follows the finished product into your plant, checking on performance in actual operation. It includes hundreds of sample melts in experimental furnaces, Rockwell tests for hardness, microscopic examinations for grain size, repeated alternating stresses in fatigue machines, elastic limit determination, exact measurements of tensile strength, electrical and thermal conductivity.

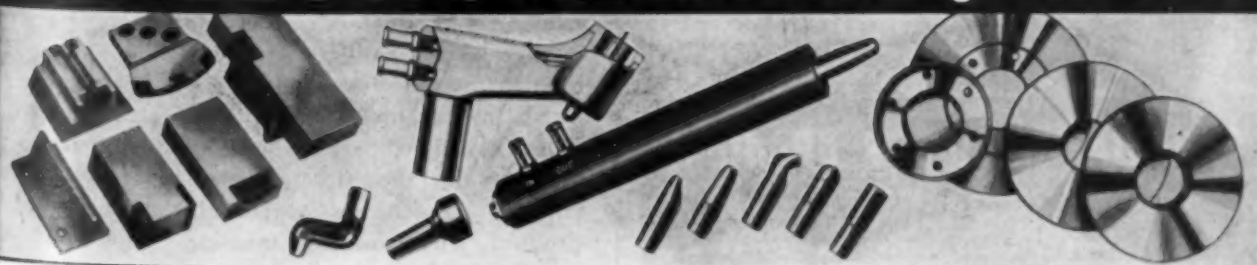
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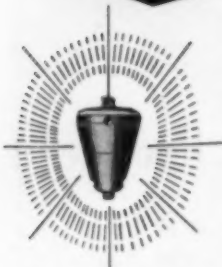
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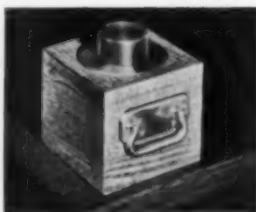
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Inspection in Manufacturing

(Continued from page 116)

which the sampling plan will assure over a long period of time. The process average (PA) is the normal per cent defective which is to be expected from the process.

To determine what AOQL value should be adopted, it is necessary to decide upon a maximum average per cent defective which may be permitted without serious consequences to the product user.

Inspection Layout—After the AOQL value has been established, definite instructions in the form of a "sampling layout" should be provided for the inspector's use. He should record the results of his inspection at the time of his observation. These records should be summarized periodically, and the process average (PA) should be computed at least once every six months.

Control Chart—The per cent defective is plotted and control limit lines are drawn around the process average to indicate the variation that may be expected due to random sampling. These control limits are determined by the following formulas:

Upper control limit for fraction defective

$$= p + 2 \sqrt{\frac{p(1-p)}{n}}$$

Lower control limit for fraction defective

$$= p - 2 \sqrt{\frac{p(1-p)}{n}}$$

where p = process average fraction defective

n = average number of articles in first sample inspected during the summary period.

Rejected material should be repaired and returned for reinspection as one lot.

Changes in AOQL and PA—There is no assurance that the value originally selected for an AOQL will continue to be the most satisfactory in view of changing factors relating to the product.

If the process average has been reduced, an attempt should be made to make the change permanent, or if it has been increased, the cause should be eliminated.

Interpretation—As long as the plotted points of the per cent defective remain within control limits, the fluctuations are no greater than may reasonably be expected from a uniform manufacturing process. However, if a point goes above the upper control limit, the cause may be defective workmanship, defective raw materials, or even a change in the severity of inspection. If a point goes below the lower control limit, the cause may be an improvement in quality or a change in the definition of a defect through misinterpretation or changes in inspection equipment or method of check. To achieve control of the quality of a product, direct and immediate action must be taken in order to stem unfavorable trends.



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Gasolene to send 1,000 bombers
over Germany every 24 hours.**

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dedicates one of the world's largest 100-Octane and Butadiene Plants

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Created from the ground up, it includes the very latest discoveries and inventions; and it is wholly dedicated to bringing the War to an earlier close. This great accomplishment is an outstanding example of what can be achieved by the winning team of Government and Industry . . . working together, shoulder to shoulder, in the battle for Freedom and Peace.

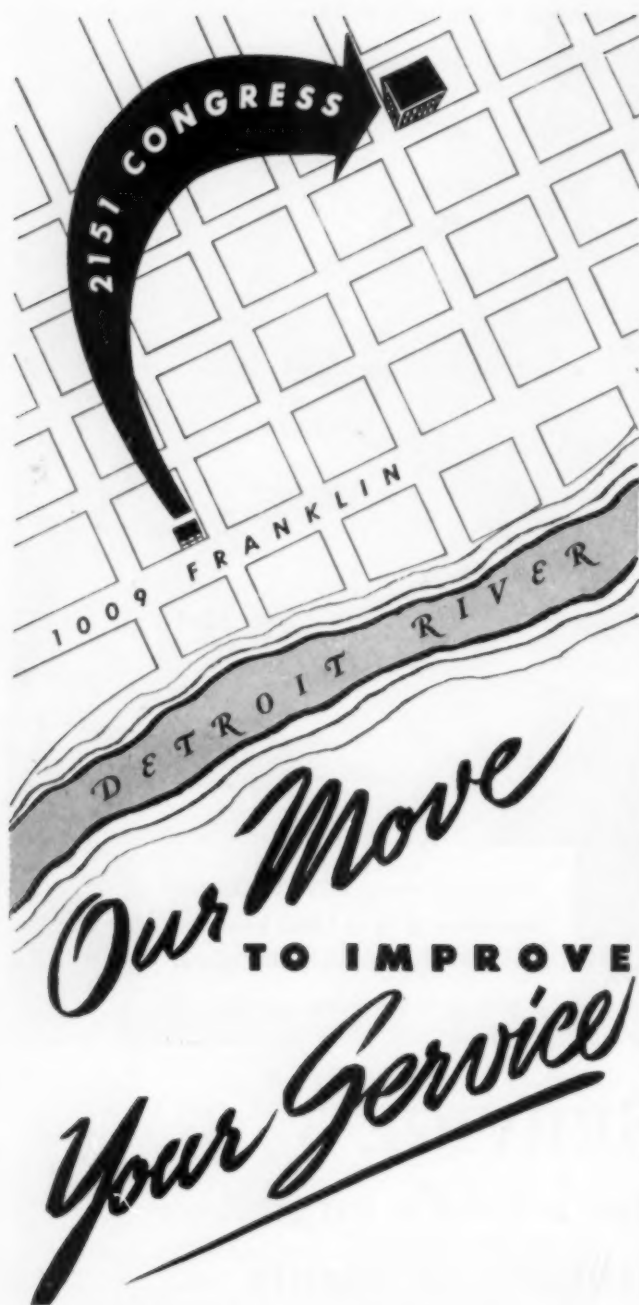
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Welded Armored Vehicles*

THE INCREASING TEMPO of mechanization in this war has emphasized the urgent need for vastly increased output of armored fighting vehicles. In the forefront of this general advance has been the increased use of electric arc welding, particularly for the hulls and turrets of armored fighting vehicles, including tanks. At the same time, an important extension in the application of welding has included its use in field repairs. Battle experience in Libya and the Middle East has shown that welding of damaged hulls of both tanks and armored cars can be carried out more effectively than repairs by any other process. A study of the effect of shell fire on welded joints has proved that they can take tremendous punishment and retain a large measure of fighting efficiency.

In the early types of tanks considerable danger to the crew arose from flying bolt and rivet heads, which became lethal weapons under attack by projectiles of heavy caliber, even where the armor itself was not defeated nor the tank put out of action. This hazard has been surmounted, but by uneconomical methods, involving use of studs, screwed bolts, drilled and tapped holes in armor plate, operations causing high consumption of expensive drills and taps. The necessity for all joints to be immune to bullet splash is a further complication of design.

The alternative from a production standpoint is to profile all plate by machine gas cutting and to fabricate by arc welding, provided no reduction in immunity and serviceability is introduced thereby. Far from this being the case, there is now ample evidence to prove that the welded tank is superior in withstanding punishment under attack in battle and, at the same time, its inherent structural rigidity is an important factor in reducing mechanical wear and breakdown. At the same time, complete water-tightness for fording in shallow waters and over marshy ground can be guaranteed.

Every scout, reconnaissance, and armored car produced in Great Britain since the outbreak of war has been provided with welded hulls and turrets. As there are many thousands of these vehicles in service, welding procedure has been thoroughly established on sound lines.

Fabricated work of this type is greatly facilitated by well-designed jigs and manipulators, in which the hull can be turned for down-hand welding of the joints. Plate sub-assemblies are welded in jigs so designed as to give controlled restraint to the plates, after which the welded sub-assemblies are put into the main jig and manipulated for final welding in the down-hand position.

*Abstract of article in *The Engineer*, June 18, 1943, page 485.

Rapid plate edge preparation prior to welding has been greatly accelerated by the extensive use of flame machining, a process combining accuracy with speed. Progress in the welding of armor for medium and heavy tanks has been somewhat slower, not because there have been official doubts as to the reliability of welds, but because production must be the ruling policy.

Actual construction of the hull and turret has never proved to be a bottleneck. A change-over to welding on production lines already fully planned, cooled, and operating in the manufacture of bolted or riveted tanks could not but entail a major industrial operation, resulting in a significant though temporary drop in output.

Nevertheless, it has now been established policy for some time that new designs for all types of armored fighting vehicles, regardless of their size, shall be based from their inception on welded construction.

A special branch has been appointed within the Department of Tank Design to deal with this aspect of construction, responsible for advising on and approving designs and production procedures to insure reliability and consistency in quality, and for coordinating investigational activities.

A considerable amount of research has been conducted by Government and industrial laboratories in connection with the welding and gas cutting of armor plate during the past decade. A wealth of information has been built up on the behavior of various types of welded constructions under different forms of attack, and a vast fund of experience gained in developing the most efficient manufacturing procedures and equipment.

Many problems have also been faced in the development of suitable electrodes and welding techniques and in the improvement of armor steels with regard to their weldability.

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INCREASED PRODUCTION



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Model "P-2" Powder Metals Compressing Machine. Pressure applied from both above and below for uniform density. Maximum tablet size, 4" dia. Maximum die fill, 8". Pressure, 80 tons.

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Extrusion of Airplane Parts*

By Phil Koenig

A PROCESS often called "impact extrusion" has been used to form articles like collapsible tubes for toothpaste from soft alloys. A single stroke of a press changes a slug of metal into the completed article. Similar methods are being used to form some small parts for airframes, rapidly and extremely economically, replacing castings, forgings, or machinings from solid stock.

"Impact" is hardly necessary, as small parts can be produced in conventional crank presses available in almost every shop. Speed is not necessary, except to give large numbers in a short time. Pressure is the prime necessity—unalloyed aluminum requires about 90,000 psi. pressure, while 24S alloy needs twice as much. Dies must be strong enough to withstand these pressures; working parts of dies and punches may be chromium plated to resist wear, and strongly supported and surrounded by die rings or plates. Minimum clearances are necessary to reduce flash. Once the correct dies are properly placed, dimensional tolerances are automatically insured.

There are no set limitations in regard to the form or shape of the parts. Symmetrical and cylindrical shapes might be best suited for production as far as the tools are concerned. Square, rectangular and oval, as well as unsymmetrical shapes, can be produced with equal ease after the tools have been made. There is no limit to the height which a slug can be driven. The stroke of the press might control this but the metal will flow to any extreme if the required force is applied to the tools.

Frequently it is handier to drill or punch a hole in an extrusion than to build the complicated die and stripper required to complete the piece in a single stroke press.

An example is a roller on the ammunition feed. It starts as a disk cut from a 1½-in. round aluminum alloy in soft condition, cut accurately to size from a bar in an automatic screw machine. The diameter of the (Cont. on p. 126)

*From "Impact Extrusion and Cold Pressing of Airplane Parts", S.A.E. Journal (Transactions), November 1943, page 415.

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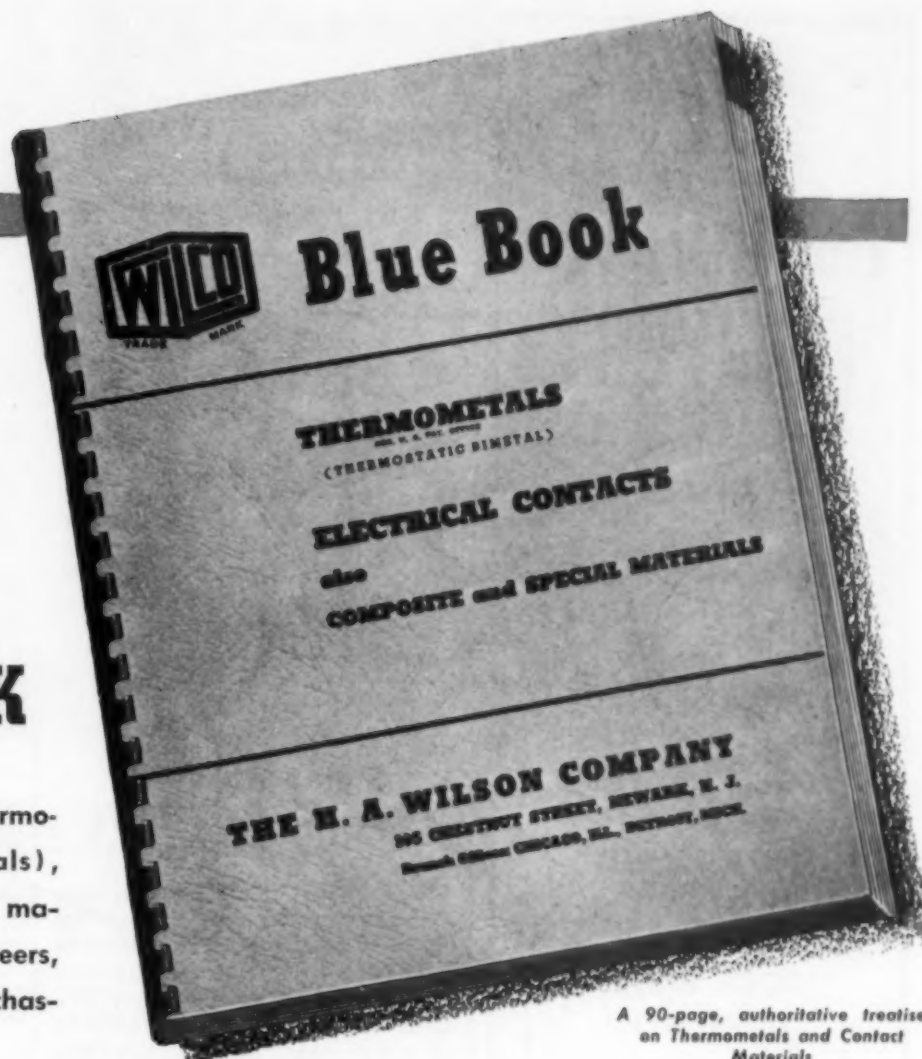
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ELECTRICAL CONTACTS

PRECIOUS METAL BIMETALLIC PRODUCTS

July, 1944; Page 125



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Extrusions

(Cont. from p. 124) finished part is slightly more than 1½ in. so the disk slips into the die easily. When the plunger comes down the disk is pressed over a ¼-in. form punch in the bottom of the die, thus putting a deep dimple in the base. Metal is forced up in an annular slot around the sides of the punch, and the result is a cup shaped a good deal like an oversized percussion cap, about 1½ in. in diameter, and 1½ in. high. The 0.9024 (+0.001, -0.000) dimension, inside diameter of cup walls, is held much closer than would be possible on a turret lathe. About 45% of the material required for machining this part from a bar is saved, and 20% of the time. Such parts, of course, can be heat treated for strength requirements after being formed from annealed alloy. ⚙

Sigma Phase in Pure Cr-Fe Alloys

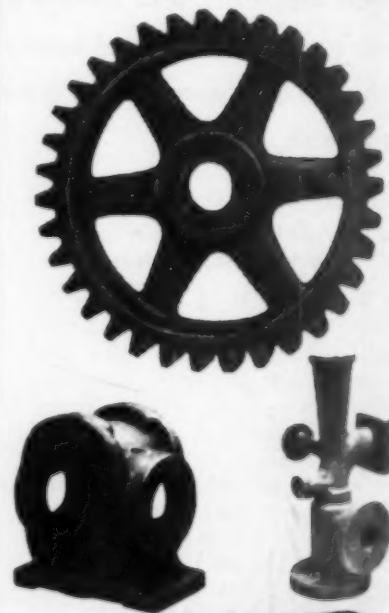
LACK OF DUCTILITY in the commercial chromium-iron alloys (stainless irons) containing upwards of 16% chromium has led to the "explanation" that they must contain a brittle constituent of some sort. In fact, this suppositious phase was used to explain the embrittlement of the 5% chromium steel tubing, when tested cold after long heating in a petroleum still. No claim was made that this phase could be seen in the microstructure when old and new tubing were compared. Interest in the matter—except for researchers—dropped off after it was discovered, by trial and error method, that a moderate amount of molybdenum in the alloy prevented brittleness after long service.

Some careful experiments on highly purified Fe-Cr alloys, described in 1931 by Adcock in *Journal of the Iron and Steel Institute*, did not locate anything but a continuous series of alpha solid solutions. More recently, American investigators of Fe-Cr-Si and other ternary systems have discovered ample evidence of a second phase, dubbed "sigma" (σ). Under these circumstances, it seemed desirable to re-examine Adcock's samples by the X-ray diffraction method, which clearly distinguishes between the very simple pattern (Cont. on p. 128)

Higher Corrosion Resistance in these STAINLESS STEEL CASTINGS

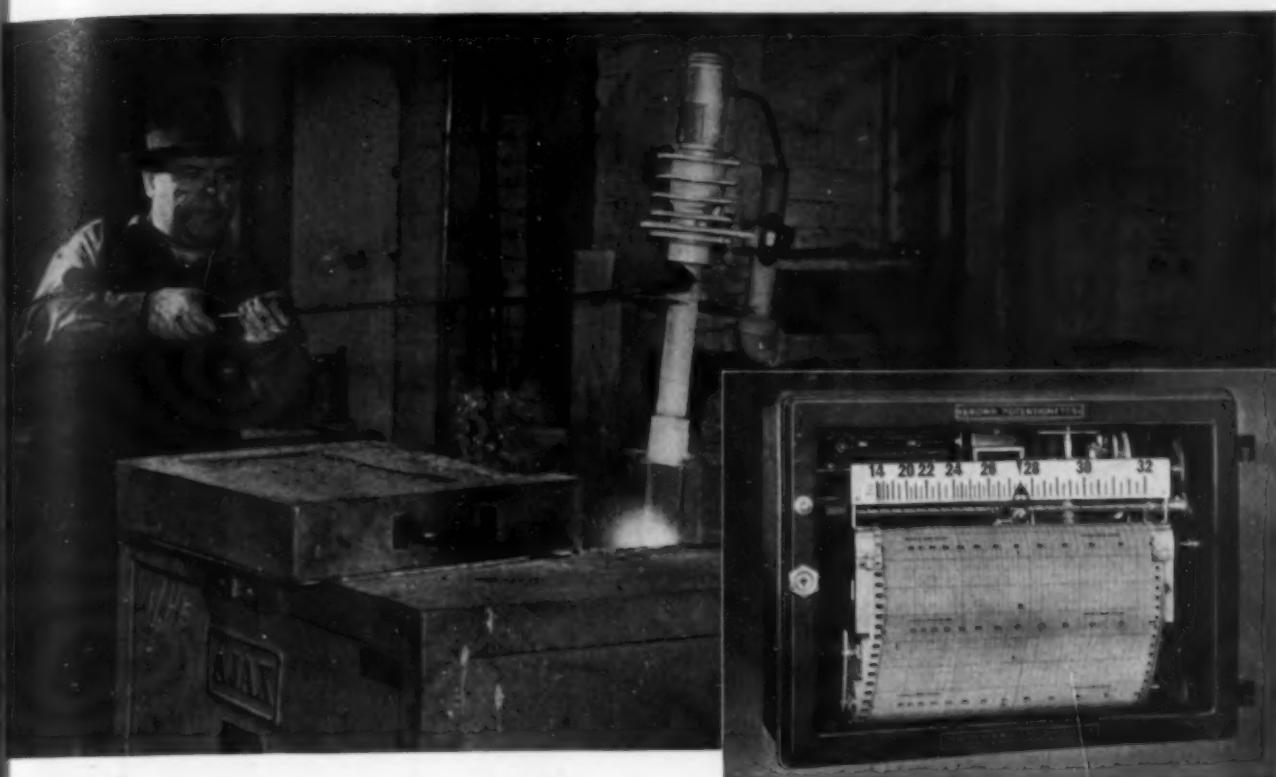
★ The casting of alloy steels is an art. Atlas metallurgists having pioneered the casting of stainless alloy steels, are thoroughly familiar with the intricacies involved. All stainless steel castings must be designed for the particular job. Therefore when a casting is in the blueprint stage, Atlas metallurgists can save much redesigning if consulted at once. There is no obligation for this valuable service. Your inquiries are invited.

Write for Illustrated Bulletin



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RADIAMATIC Solves Control of **HIGH SPEED SALT BATHS**

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The above illustration is typical of many Radiamatic installations where thermocouple maintenance has been eliminated.

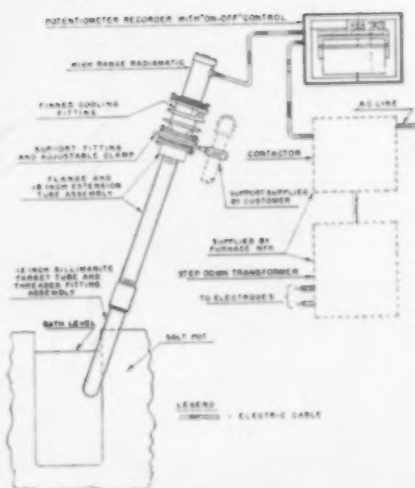
Users of Brown Radiamatic Pyrometers have found temperature measurement control by the radiation principle highly accurate and dependable. It safeguards against thermocouple protecting tube failure, which can cause serious damage to recording instrument if subjected to the high A.C. potential in salt bath. The use of a sillimanite target tube insures long life and makes it possible to continuously measure deep bath temperatures.

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The Radiamatic is self-contained—measures temperatures beyond the range of conventional thermocouples—built-in compensator compensates for ambient temperature changes up to 250° F.

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Write for Bulletin 5101—The Brown Instrument Company, a division of Minneapolis-Honeywell Regulator Company, 4503 Wayne Avenue, Philadelphia 44, Pennsylvania. Offices in all principal cities. 119 Peter Street, Toronto, Canada—Wadsworth Road, Perivale, Middlesex, England—Nyborkajen 7, Stockholm, Sweden.



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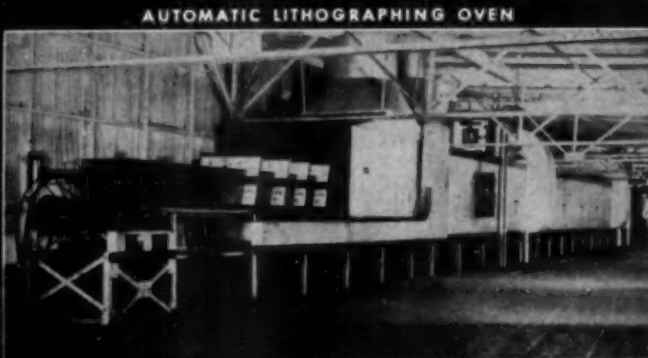
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Sigma Phase

(Cont. from page 126) produced by the alpha solid solution and the very complicated pattern of the sigma phase. This has now been done by A. J. Cook and F. W. Jones in the British National Physical Laboratory. They find, incidentally, that structural changes occur much more slowly in bars or sticks than in heavily cold worked powders filed from them.

Briefly their conclusions are that the alpha phase is stable in pure binary iron-chromium alloys above 820° C. (1510° F.) at the 600° C. (1110° F.) level, the sigma phase only is found in well annealed alloys between 44 and 50 atomic % chromium; at that same temperature, duplex alpha plus sigma structures exist at 26 to 44 atomic % chromium on the one side, and 50 to 71% on the other (a range of composition much wider than reported by German scientists). The alpha boundary, then, consists of a parabola, open downward with axis vertical at about 47 atomic % chromium, reaching as far up as 820° C. and the two branches passing through 26 and 71% at the 600° C. level. The sigma boundary is a much narrower parabola on the same axis, tangent at the 820° C. level, and its two branches passing through 44 and 50 atomic % chromium at the 600° C. level.

A pronounced hysteresis effect occurs in the temperature range from 770 to 820° C. (1420 to 1510° F.). For example, an alloy containing 47 atomic % chromium—about median composition of pure sigma phase—can be converted by appropriate heat treatments into pure alpha (annealing at 900° C.) or a mixture of alpha and sigma (brief heating of an alpha specimen at 750° C.). If these samples are then annealed for 7 days at 780° C. (1435° F.), 17 days at 800° C. (1475° F.) or 26 days at 810° C. (1490° F.) no change could be detected in the structure of any of the three. "The fact that either the alpha or the sigma phase can exist for such long periods without any noticeable change [in a region where theoretically sigma is the stable phase] suggests that this is a case of true hysteresis and is not merely due to a very high 'time of relaxation'; there is, therefore, very little possibility of accurately establishing the phase boundaries in this temperature interval."

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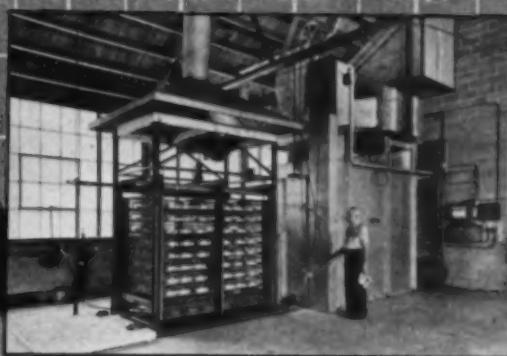
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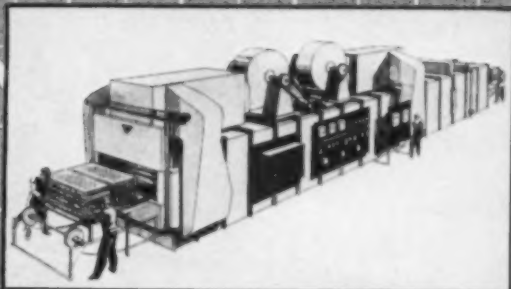
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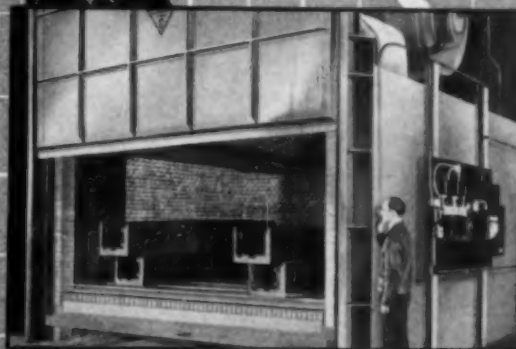
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Despatch furnace for heat treating magnesium and aluminum castings. Note elevator and quench.



Despatch furnace for processing aircraft sheets. Transports, heat treats and quenches automatically.



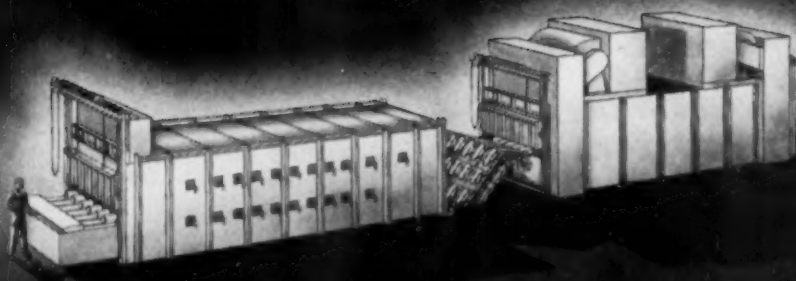
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Welds in German Tank Armor*

By Col. Scott B. Ritchie

AN EXAMINATION of German welded armor in the field disclosed a few cases where cracks in welds had been repaired before the vehicle had been captured or become a complete casualty. It does not appear that the old welds are cut out before the repair is made. Workmanship is rough and normally ferritic electrodes are used. While it is reported that the welds in German tanks perform well under normal service conditions, it is known that the behavior of the welding in German PzKw III and PzKw IV tanks under artillery fire has been somewhat erratic. Some of the welds, after repeated hits on the vehicle, give little indication of failure; in others, cracks develop in joints even after a single hit. These cracks may run for considerable distance along the joint.

Armor 11 mm. (0.436 in.) thick, taken from a German PzKw III tank in January 1943, was found to be cross-rolled, homogeneous and good quality steel, quenched and drawn to 320 to 340 Brinell. This armor is similar to S.A.E. 4150 and to some of the armor that was used in this country for riveted and bolted fabrication. Fragments in the heat-affected zone adjacent to the weld metal had a maximum hardness of 690 Vickers. In the weld metal itself the maximum hardness observed was 440 Vickers. The welding procedure employed was apparently two-pass sequence. Excessive porosity was observed and it was more prevalent at the fusion line between the two weld layers. Lack of fusion was especially noticeable between the base metal and the first pass. The chemical analysis of the plate was C 0.44%, Si 0.25%, Cr 1.30%, Mo 0.50%, V 0.17%, Cu 0.18% and Ni trace. (Cont. on page 132)

*Extracts from "Welded Weapons in War", presented at the October 1943 meeting of the American Welding Society. *The Welding Journal*, November 1943, page 893.

R-301

The Aluminum Alloy that is

**STRONG,
CORROSION
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The superior workability of R-301 offers a major advantage in forming curved or flanged parts.

PLANE DESIGNERS wanted a higher strength aluminum alloy for increased performance. Aircraft shopmen wanted an aluminum alloy of good workability in order to reduce production time. Users of aircraft wanted an aluminum alloy with good corrosion resistance, to withstand any atmosphere and climate.

Reynolds' Metallurgists, reading these needs, created R-301.

R-301 is a high-strength aluminum alloy core, internally bonded with a corrosion-resistant, medium-strength aluminum alloy cladding. The core and cladding alloys respond to the same heat treatment—resulting in a final product possessing high strength.

R-301 in the solution heat-treated temper is stable and more workable than any other high-strength aluminum alloy in the corresponding temper—thereby eliminating costly post-forming heat treatment and subsequent distortion of aircraft parts.

R-301 is being produced in three tempers, suitable for a wide range of applications. Inquiries are invited. Reynolds Metals Co., Aluminum and Parts Division, Louisville, Kentucky.



Heavy, bending rolls, forming an armor hood for the pilot's compartment. R-301 can be cold-rolled to shape.



R-301 drills and routs to sharp, accurate contour. The hard-surface cladding reduces the hazard of accidental scratching.



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German Armor

(Cont. from p. 130) The composition of the armor of a "Tiger" tank ran around 0.50% C, 2.50% Cr, and 0.60% Mo; this was wrought homogeneous armor with hardness of about 325 Brinell.

The German conception of an armor weldment is quite different, apparently, from ours. It appears that our enemies make an effort to develop a hardness in the weld metal equivalent to that of the base metal. Composition of the weld metal is markedly different from that used in this country, and is interesting because of the high alloy content in the ferritic type weld. In one of the German maintenance vehicles taken in Tunisia we found welding rod, some coated and some bare. The bare rods all appeared to be plain low carbon steel. Likewise, the core wires of the coated rods were plain low carbon steel, but the presence of silicon and chromium in the coating suggests the possibility of a hard facing electrode.

Some of the salient characteristics of German welding observed so far are:

1. Mortised joints.
2. Non-uniform quality of welding, with most of it decidedly inferior to ours as judged by ballistic performance.
3. Susceptibility of failure in the fusion zone of welds under shock conditions in which the welding bead breaks from the base metal, sometimes coming out as a strip.
4. In some joints the notch was not completely filled, flush to the surface of face-hardened armor. Usually the weld metal is from ⅜ to ¼ in. below surface of plates about 2 in. thick.
5. In cases where notch is completely filled, the root deposit is of 18-8 austenitic steel with hardness of about 280 Vickers; the center deposit is ferritic or low alloy with a hardness of approximately 440 Vickers; the top deposit is of C-Ni-Cr-Mn-W type with approximate hardness of 525 Vickers.

6. The Germans first used homogeneous plates, then homogeneous plates (Cont. on p. 136)

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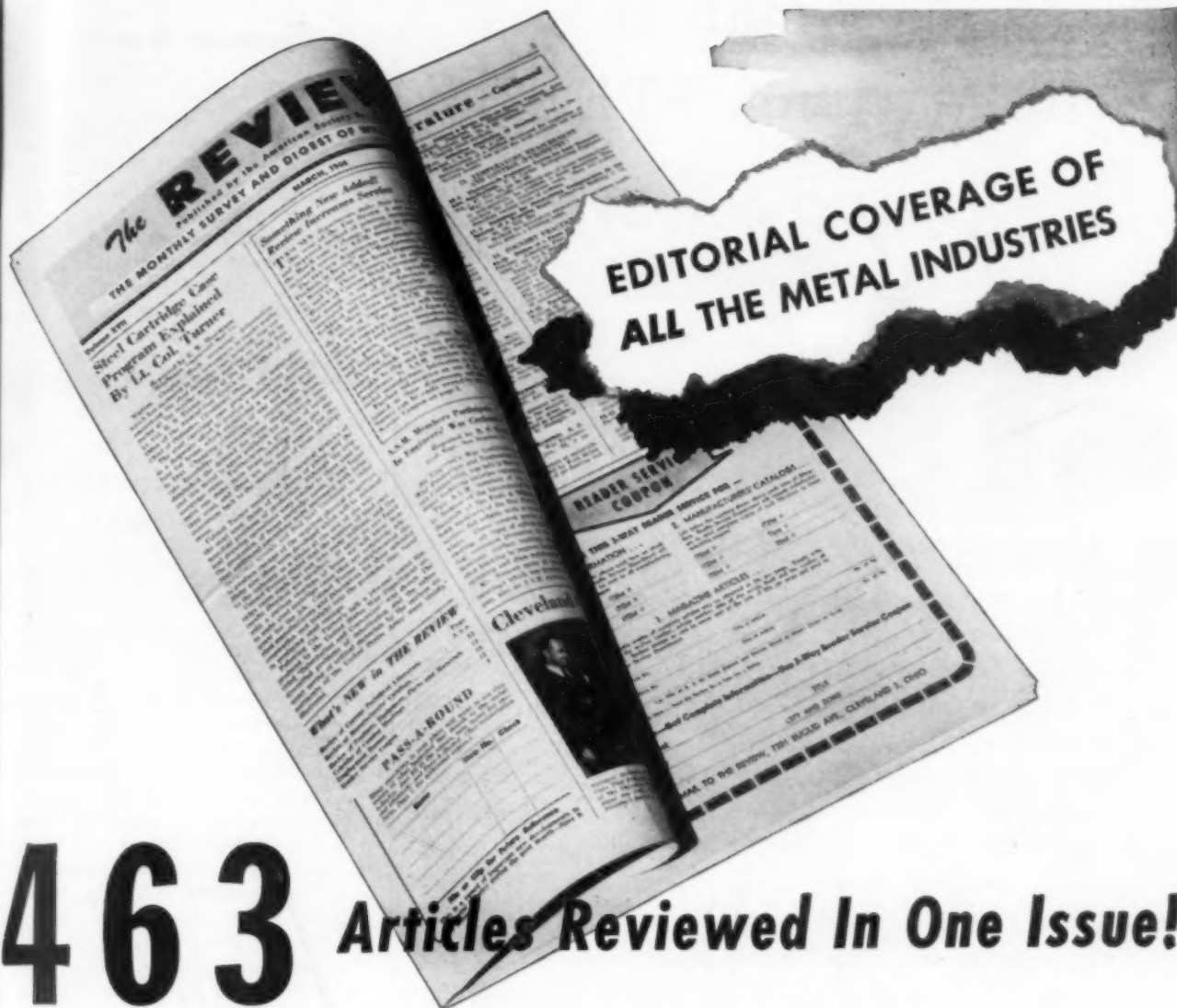
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1/9 and 2/9 page advertisement was ideally located next to live editorial material of direct interest to the advertiser's market.

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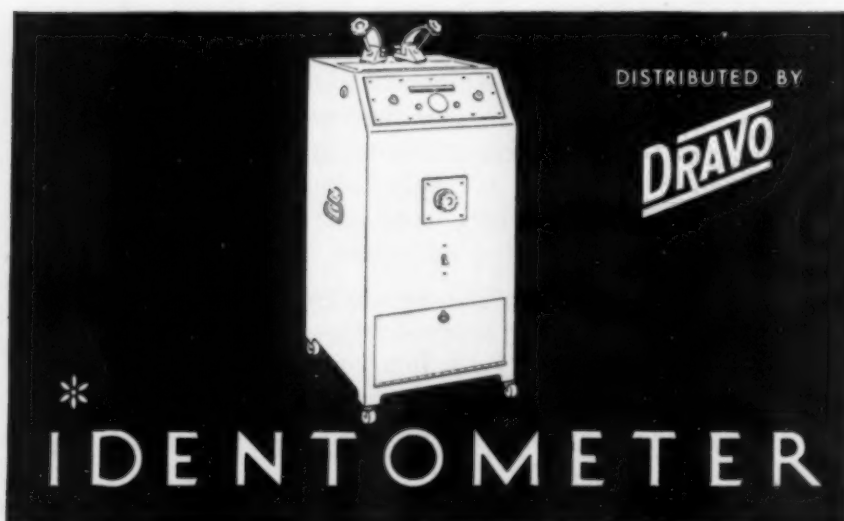
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Provided with a known sample of most rolled or forged ferrous alloys, he can tell instantly if unknown pieces of almost any size or shape and in most stages of processing are: (1) of the same or different chemical composition, if the physical structures are the same; (2) of the same or different heat treatments, if the chemical composition is the same.

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AN ELECTRICAL INSTRUMENT FOR THE INSTANT AND ACCURATE IDENTIFICATION OF MOST ROLLED OR FORGED FERROUS ALLOYS BY THE USE OF REFERENCE SPECIMENS

German Armor

(Starts on p. 130) plus preferential face-hardened plates bolted over the homogeneous plates and separated from them by thin washers; then a combination of two face-hardened plates separated 4 to 6 in. by spacers welded to the inside plates. (Outside plates were bolted to the spacers.) This indicated that our enemies attempted to improvise to meet changing requirements imposed by our improved projectiles and anti-tank weapons. ©

Architectural Aluminum*

By G. O. Taylor

ALUMINUM and certain of its alloys are admirably suited for architectural purposes, and have been used more extensively than is generally known. The lightness of aluminum, the variety of forms available, the ease of fabrication, and the diverse surface finishes obtainable offer outstanding potentialities to the architect and craftsman — when corrosion resistance is assured by well-proven and economical methods.

The type of aluminum alloy most favored for architectural metal work in Great Britain is that containing from 2 to 9% of magnesium, with or without the addition of small quantities of other elements, such as manganese or chromium. These alloys do not need any heat treatment to possess their maximum mechanical properties, the strength being controlled by the magnesium content and the degree of cold work during fabrication. Very high tensile strength, exceeding that of mild steel, can be obtained in wrought forms, with magnesium contents of 6 to 9%, but only at the expense of workability.

The alloys containing from 2 to 4% magnesium are most favored. They are reasonably strong and sufficiently ductile to withstand a considerable degree of cold deformation. They have the highest resistance to corrosion yet available in light alloy materials.

Fabrication — These alloys can be produced in all forms, including complicated extruded (See p. 140)

*Abstracted from "Aluminum in Architecture of the Future", by G. O. Taylor, *Metallurgia*, February 1943, p. 147.



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"Instead, the Cyclograph made it possible for us to inspect all this material in four days, with but one or two stock-

room attendants. After this inspection it was of course possible to retain the non-magnetic material in the original undamaged and unopened packages.

"According to Cyclograph findings, a total of 2,672 pounds possessed magnetic properties. In subsequent re-checking of individual rods in the separated bundles by means of a magnet, one entire bundle was found to be magnetic, while at the other extreme only one rod showed magnetic properties. 70 rods to each bundle. Yet even a single magnetic rod could easily be de-

tected regardless of its position in the bundle!

"Aside from marked savings in man-hours and expense, the Cyclograph made it possible for our customers to proceed without interruption or delay in the processing of vital war equipment, with complete assurance of 100% uniformity in welding electrodes."

All of which is once more indicative of the possibilities of this new metallurgical checking, inspection and sorting technique.

Write for Literature...

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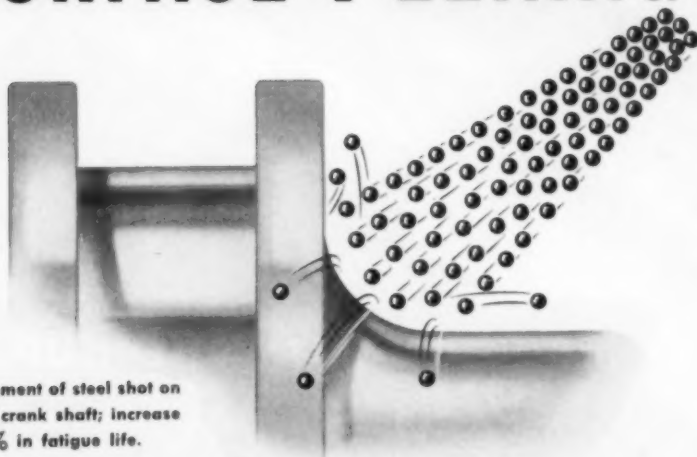
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Large parts are peened individually; small parts may be mass peened.

Surface-peening generally increases fatigue life several hundred per cent. Numerous examples prove this. It is being used extensively in several fields, notably automotive and aeronautical—and is spreading rapidly.

Possibly you, too, could use Surface-Peening to advantage in improving your metal products. Our engineers will be glad to help you. Ask for Surface-Peening Bulletin.

The W. W. SLY MFG. CO.

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Aluminum

(Cont. from page 136) sections, thin drawn sections, sections drawn on wood cores, thick or thin rolled sheets, all shapes and commercial sizes of tubing, wire, rivets, nuts and bolts, wire mesh and woven screens. (Sand or die castings can be made of appropriate alloy compositions for individual items.)

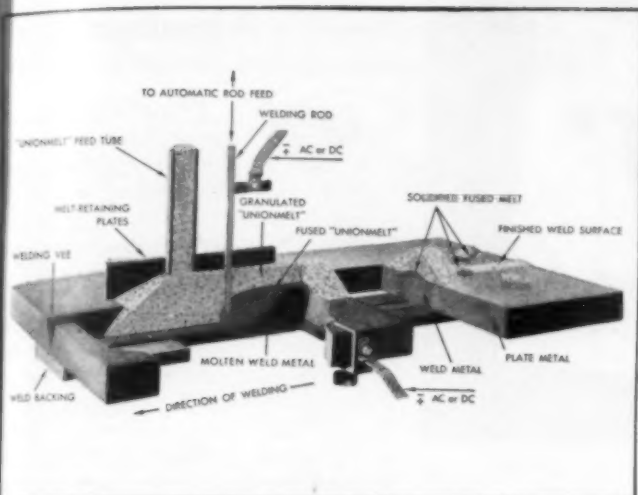
Manipulation of extrusions does not present any difficulty, since the alloys can be worked in a manner similar to that adopted for mild steel. Some deformation can be carried out with the metal in cold condition; when necessary it is softened in the region of deformation by heating to about 625° F. All normal machining can be carried out with ease; slight alterations in tool design are sometimes necessary for highest speeds.

Welding rod should be of the same composition as the members to prevent a difference of color at the joint. Even then the deposited metal sometimes shows a crystal-line structure due to slight etching in subsequent anodizing. The work should be chamfered from the back, so that a minimum of deposited metal is evident at the front surface. Soldering demands a special technique and special solders, and is not recommended for anodic finishing or for outdoor use, unless the joints can be protected.

Surface Finishes in great variety can be applied to aluminum and the aluminum-magnesium alloys—greater, indeed, than is possible with any other metal used in architecture. The most popular mechanical finish is that resulting from polishing or buffing operations. Where the atmosphere tends to be warm but humid, the aluminum-manganese alloys require far less maintenance than other alloys in order to retain their polished surface. Even when continually handled, as door frames and hand-rails, the aluminum-manganese alloys are immune from tarnishing. Outdoors in an industrial atmosphere these outstanding properties are revealed to the best effect.

The electrochemical process of anodic oxidation has superseded all purely chemical immersion processes for decorative surface coatings. The anodic film is a natural mordant for dyestuffs.

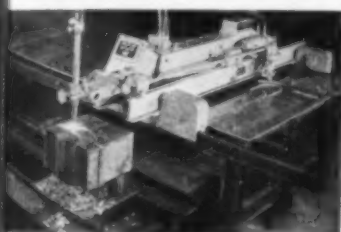
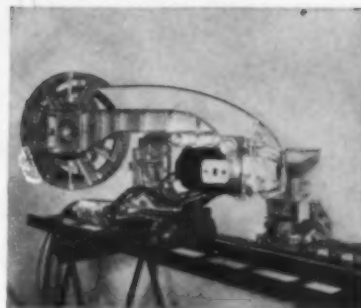
By variation of process factors and preparatory finish given to the metal surface, the anodic oxidation process provides (Cont. on p. 144)



This sketch shows how a UNIONMELT butt weld is made.

UNIONMELT WELDING

UNIONMELT electric welding is a unique automatic process that makes welds of unusually high quality in any thickness of metal at high speeds. Once the speed and current values are established by the operator, the "human element" is eliminated as a factor in producing good welds. UNIONMELT welding is done under a protective blanket of a special granulated material—without flash, glare, or sparks. The rod is fed automatically as work progresses and is thoroughly mixed with the molten base metal. For these reasons, UNIONMELT welding is widely used in the fabrication of pressure vessels, pipe, railroad equipment, tankers, and ships.



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Included in the OXWELD line of apparatus are portable and stationary oxy-acetylene machines for cutting shapes or straight lines; flame-hardening apparatus; bar and automatic welding equipment; and tractor

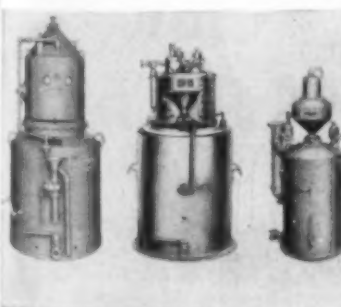
billet cut-off machines; automatic welding equipment; and tractor units for plate-edge preparation.



WELDING RODS AND SUPPLIES

The many kinds and sizes of OXWELD high quality welding rods make it possible to select the one that will give best results on each job. The OXWELD line also includes fluxes, gloves, goggles, light-

ers, hose, and asbestos paper. Rods and supplies may be ordered from Linde or from automotive and industrial jobbers.



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OXWELD acetylene generators are made for both portable and stationary use — with maximum generating capacities of from 30 to 9,000 cu. ft. per hour. OXWELD manifolds central-ize the oxygen and acetylene supply from cylinders.

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Oxy-acetylene apparatus which may be ordered from Linde includes oxy-acetylene blowpipes for all welding and heating work; oxy-acetylene cutting blowpipes, cutting attachments, and nozzles; and oxy-acetylene descaling and flame-priming equipment. OXWELD apparatus is supplied from Linde offices and warehouses. The PUROX and PREST-O-WELD line, and PREST-O-LITE air-acetylene appliances for soldering and brazing, are distributed by industrial and automotive jobbers.



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A booklet describing use of LINDE oxygen, PREST-O-LITE acetylene, UNION carbide, and OXWELD apparatus in these and other processes will be sent without charge on request. Ask for Form 5268A.



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These new compounds provide baths which: do not increase in viscosity; reduce sludging to a minimum; permit a long pot and/or electrode life expectancy; prevent decarburization.

AEROHEAT 1200 is recommended for general use in the temperature range of 1325°F.-1550°F. AEROHEAT 1000 with a temperature range of 1125°F.-1700°F. is recommended only for use at temperatures not suitable for AEROHEAT 1200.

Physical Properties

	AEROHEAT 1000	AEROHEAT 1200
Melting Point	1020° F.	1225° F.
Specific Gravity at 1500° F.	136 lbs./cu. ft.	96 lbs./cu. ft.

Operating Characteristics

(note low-cost features)

1. Non-decarburizing
2. No rectifiers
3. A minimum of sludge
4. Low and unchanging viscosity
 - (a) Low drag-out losses
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5. Long pot and/or electrode life expectancy.

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Aluminum

(Starts on p. 136) a wide range of stainless, wear resistant finishes ranging through natural colors such as frosted silver, silver matte, and antique silver to all the myriad colors that can be obtained by dye stuff combinations. By masking stenciling and etching processes multi-color, printed or patterned designs can be reproduced, so that the decorative possibilities are virtually unlimited.

Colored anodized finishes exposed indoors remain good indefinitely, but the range of colors fast to sunlight and weather for exterior uses is more restricted.

The uses of light metals in architecture of the future will undoubtedly be many and varied both for structural and decorative purposes. Cast aluminum alloy facings have the important advantage that since the corrosion products of aluminum are colorless surrounding stonework can never become stained or discolored. Another application in which considerable development is likely is the application of corrosion resistant alloys to cast ornamentation statuary and monuments. Material anodized to a silver finish has been extensively used for doors, window framing, panels, spandrels, grilles and escalator casings.

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

METAL WORKING • FABRICATION

Powdered metal presses. Kux Machine Co. Bulletin 1.

Forging presses. Ajax Mfg. Co. Bulletin 2.

Horizontal extrusion presses. Hydropress, Inc. Bulletin 3.

36-page pictorial story of the Ceco-stamp. Chambersburg Engineering Co. Bulletin 4.

Cutting Oils. Cities Service Oil Co. Bulletin 5.

Presses for Powder Metallurgy. F. J. Stokes Machine Co. Bulletin 7.

Information and data on straightening press. Anderson Bros. Mfg. Co. Bulletin 10.

Properties and uses of cutting oils. Gulf Oil Corp. Bulletin 8.

Surface coated abrasive belts. Minnesota Mining & Mfg. Co. Bulletin 12.

Savings in oils, tool bits, grinding wheels. Sparkler Mfg. Co. Bulletin 15.

New catalog illustrates standard, non-standard, and special tools. Kenametal, Inc. Bulletin 250.

Mounted wheels. Handee and Hi-Power tools. Chicago Wheel & Mfg. Co. Bulletin 21.

Air tools in steel mills and foundries are pictured in new booklet by Ingersoll-Rand. Bulletin 255.

Complete and valuable study of "Machining of Metals", including chip formation, is offered by National Refining Co. Bulletin 335.

Safe-T tongs and their use in materials handling are described in new booklet by Heppenstall Co. Bulletin 434.

63-page pocket booklet shows useful tables of weights and measures used in the metal industry. Mesta Machine Co. Bulletin 441.

Practical data sheet describes cutting and grinding compound. Diverserby Corp. Bulletin 447.

8-page general catalog outlines the hard facing alloys and overlay metals of this company, with many illustrations and typical applications. Wall-Colmonoy Corp. Bulletin 484.

Attractive 16-page booklet describes the new "MX" grinding tools, citing many features and applications. Carborundum Co. Bulletin 518.

Struthers Wells Corporation's Tangent Bender and its ability to edge bend sheet metal in the lighter gauges is described in illustrated 8-page leaflet. Bulletin 520.

This company has issued two new booklets showing new price lists for sintered carbides. Firth-Sterling Steel Co. Bulletin 486.

"Quality Control" is the title of this new 64-page pocket size handbook on scientific inspection. Continental Machines, Inc. Bulletin 47

20-page booklet discusses typical problems involved in the selection and application of water-mix oils. A. Stuart Oil Co., Ltd. Bulletin 48

Attractive new bulletin describes the Spencer Turbine Co.'s Sump-Vac, a new portable vacuum product which is said to clean machine sum tanks in 2 to 10 min. Bulletin 48

FERROUS METALS

Republic Steel Corp.'s second edition of National Emergency Steel tells you all about these new steel Bulletin 345.

Page after page of useful technical data and reference tables on tool steels. Latrobe Electric Steel Co. Bulletin 367.

Steel Data Sheets. Wheelock, Loy & Co. Bulletin 25.

Use Handy Coupon Below

for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 166, 168, 170, 172, 174, 176, 180, 182, 184, 186, 188, 190 and 192.

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Check or circle the numbers referring to literature described on these 15 pages.

1	45	97	139	172	206	319	361	399	447	477	502	523
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5	62	102	146	177	240	325	365	409	453	482	507	527
7	65	103	147	179	246	327	366	410	454	483	508	528
8	66	106	148	180	250	328	367	411	455	484	509	529
10	67	107	149	182	255	329	368	422	457	486	510	530
12	70	114	150	183	258	331	369	424	458	487	511	531
15	71	115	152	185	271	333	372	426	459	489	512	532
21	72	116	154	186	288	335	374	428	461	490	513	533
25	78	117	155	190	292	337	375	433	462	491	514	534
26	79	118	156	192	296	338	376	434	463	492	515	535
30	82	119	158	193	297	339	380	436	465	493	516	536
31	85	123	161	197	301	343	383	437	466	494	517	
33	86	128	162	199	305	345	384	438	469	495	518	
35	89	132	164	200	307	347	385	440	470	497	519	
40	93	134	167	201	314	353	388	441	471	499	520	
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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Molybdenum wrought steel. Molybdenum Corp. of America. Bulletin 26.

Free Machining Steels. Monarch Steel Co. Bulletin 30.

Chemical analyses, shapes and sizes of Joslyn stainless steel products. Joslyn Mfg. and Supply Co. Bulletin 297.

Tool Steels. Bethlehem Steel Co. Bulletin 31.

Enameling iron sheets. Inland Steel Co. Bulletin 33.

Loose-leaf reference book on molybdenum steels. Climax Molybdenum Co. Bulletin 35.

Aircraft Alloy Steels. Joseph Ryerson & Son, Inc. Bulletin 40.

Kinite alloy tool steel bar stock. Boker & Co., Inc. Bulletin 258.

New Catalog C makes it easy to get International Nickel Co. literature, and it presents brief description and index to a wide variety of booklets. Bulletin 305.

"Graphitic Booklet" gives complete information on new, free-machining long-wearing steel. Steel & Tube Div., Timken Roller Bearing Co. Bulletin 307.

HWD hot work die steel and Sterling stainless steels are described in four new leaflets by Firth-Sterling Steel Co. Bulletin 323.

Engineering and comparative information on porcelain enameled iron is presented in new illustrated booklet by American Rolling Mill Co. Bulletin 376.

New booklet gives full information on N-A-X high tensile and N-A-9100 Series of alloy steels. Great Lakes Steel Corp. Bulletin 328.

Attractive new catalog describes the line of steel offered by Peninsular Steel Co. Bulletin 337.

Spindle speed calculator is handy chart to figure machining rates of bar steels. Bliss & Laughlin, Inc. Bulletin 333.

64-page booklet describes the welding of stainless steels. Allegheny Ludlum Steel Corp. Bulletin 384.

84-page tool and die steel handbook just issued by Ziv Steel & Wire Co. is a helpful guide to selection, treatment and use of these important steels. Bulletin 440.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190 and 192

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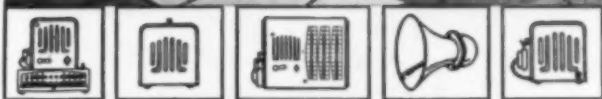
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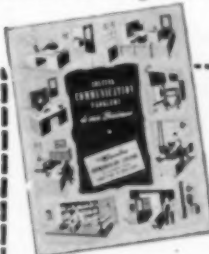
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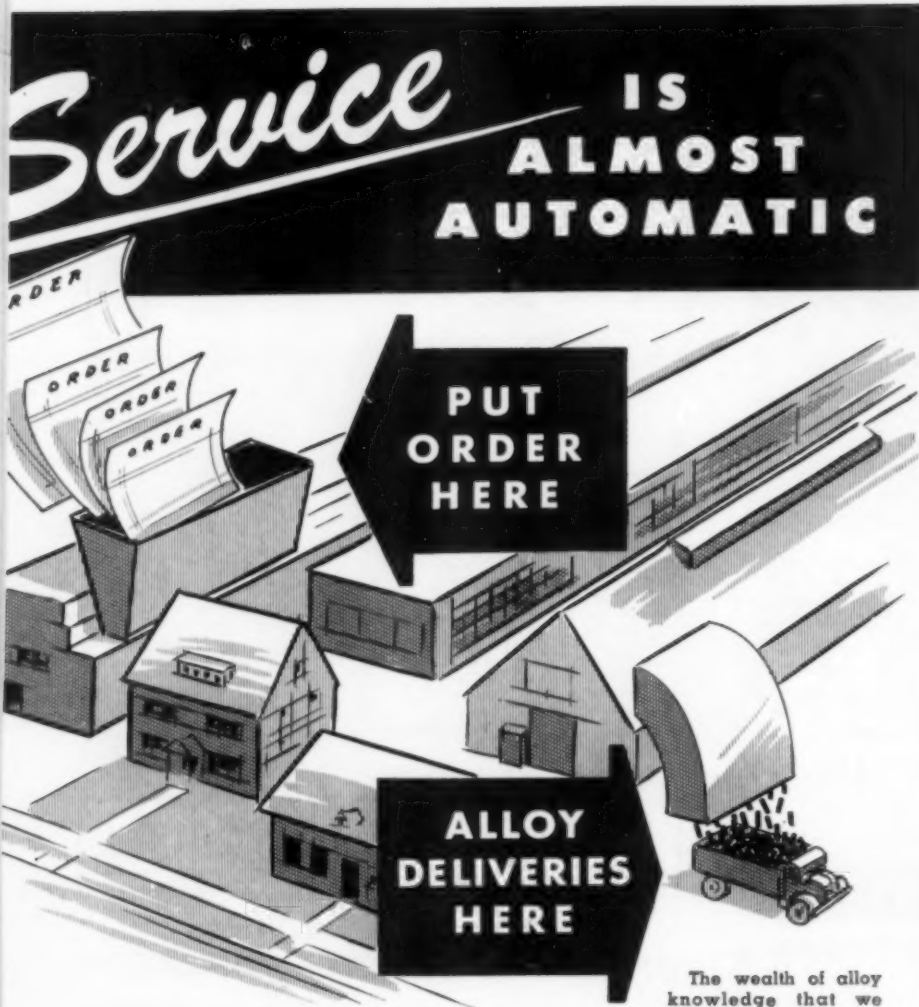
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WHAT'S NEW IN MANUFACTURERS' LITERATURE

32-page booklet which pictorially and textually amounts to a scientific treatise on two carbon steels—Speed Case and Speed Treat—has been issued by W. J. Holliday & Co. Bulletin 450.

Fitzsimons Co. issues interesting leaflet on speed case and speed treat steels. Bulletin 452.

Molybdenum-Tungsten high speed steels marketed under the general trade name Mo-Max are discussed comprehensively in 52-page book by J. V. Emmons, metallurgist for the Cleveland Twist Drill Co. Bulletin 497.

Carpenter Steel Co. offers a convenient four-color chart useful in identifying various types of stainless steels which may have become mixed in stock. Bulletin 507.

Latest data chart, Section D, No. 1, shows government "specs" for alloy steels and corresponding commercial designations. Peter A. Frasse & Co., Inc. Bulletin 533.

NON-FERROUS METALS

This "Aluminum Imagineering Notebook" presents 12 important economic advantages of aluminum and illustrates numerous examples of things which have been imagined into aluminum actualities. Aluminum Co. of America. Bulletin 472.

80-page pipe and tube bending handbook has been issued by Copper & Brass Research Assn. Bulletin 399.

Platinum Metal Catalysts. Baker & Co., Inc. Bulletin 41.

Die casting equipment. Lester-Phoenix, Inc. Bulletin 42.

Copper Alloys. American Brass Co. Bulletin 45.

6th edition of Revere Weights and Data Handbook. Revere Copper and Brass, Inc. Bulletin 296.

Rare metals, alloys and ores. Foote Mineral Co. Bulletin 56.

Dowmetal data book. Dow Chemical Co. Bulletin 51.

Two new Ampco Metal data sheets discuss forging Ampco to improve physical characteristics and use of Ampco for non-scratching feed fingers. Bulletin 314.

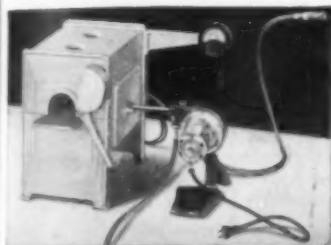
Printed information on Lithium of interest to nonferrous and physical metallurgists is available from Lithalloys Corp. Bulletin 532.

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Other Manufacturers' Literature Listed on Pages 164, 166, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190 and 192.

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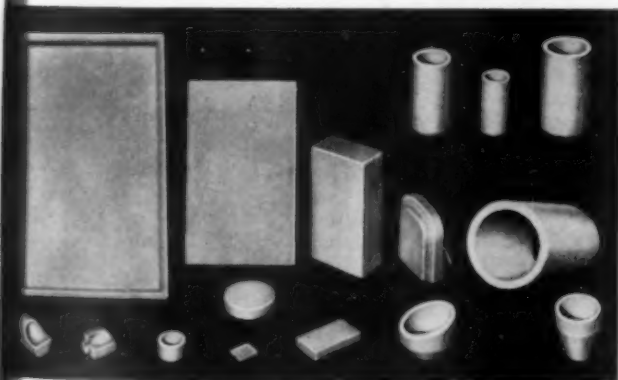
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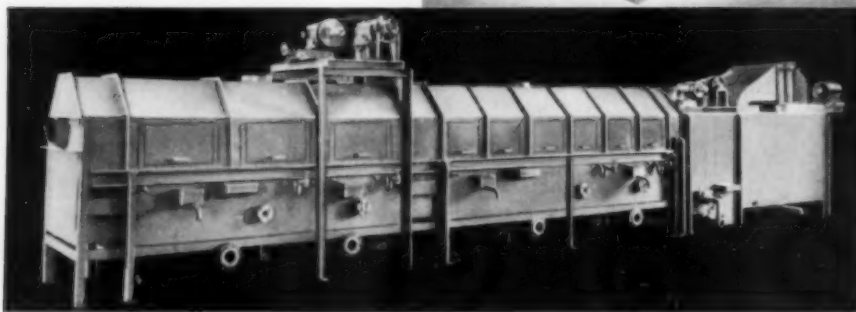
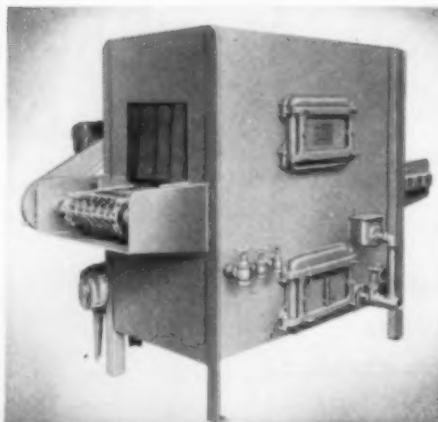
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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Sheet and strip aluminum is discussed in this 8-page booklet, giving tolerances, specifications, weight, chemical composition and physical properties. Reynolds Metals Co. Bulletin 524.

"Some Considerations in Making Test Bars" is the title of an interesting booklet by Federated Metals Division American Smelting and Refining Co. Bulletin 529.

"Designing with Magnesium" is the title of new book offered by American Magnesium Corp. Bulletin 433.

Red-X Aluminum Alloys, produced by the largest single producer of Commercial Aluminum and Magnesium Alloys, the National Smelting Co., are described, applications studied, in this 16-page file folder. Bulletin 499.

Facts on Beryllium Copper, including composition, forms available, applications and extensive additional information are presented in the new 16-page booklet by the Riverside Metal Co. Bulletin 511.

WELDING

40-page catalog reviews the progress and many applications of low temperature welding. Eutectic Welding Alloys Co. Bulletin 471.

Welding Stainless. Page Steel Wire Div., American Chain & Cable Co., Inc. Bulletin 59.

Oxy-acetylene welding and cutting Linde Air Products Co. Bulletin 60.

Welding and brazing of aluminum a new data book issued by Aluminum Co. of America. Bulletin 66.

Data book facts on spot, seam and flash welding ferrous and non-ferrous metals and alloys. P. R. Malory & Co., Inc. Bulletin 65.

Shield Arc electrodes. McKay Co. Bulletin 67.

Nu-Braze No. 4, an improved silver brazing alloy. Sherman & Co. Bulletin 288.

Two new hard-facing alloys furnished as welding rods for application by Oxy-Acetylene process are described by the Stoodly Co. in Bulletin 325.

Comparable arc welding electrodes for stainless are shown in chart issued by Alloy Rods Co. Bulletin 350.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190 and 192.

WELDING
MAKES
GREAT SHIPS

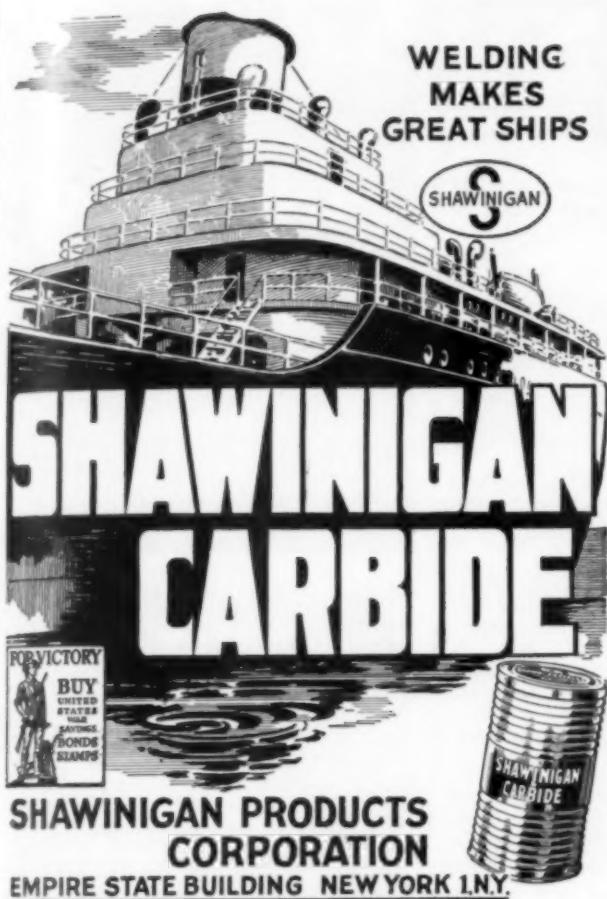
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This 275-page book covers alloys in commercial steels—why alloy steels are used—selection of alloy steels—typical commercial uses—commercial steels and manufacturing variables—high alloy steels—wear—how alloying elements may affect corrosion of steels—processing and special treatments.

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Pressure gauge, indicating ram loading . . . adjustable dial indicator shows amount of shaft run-out in pre-loaded, fully loaded, and unloaded positions.

Flexible, sensitive control by rotary control valve operated by hand lever. An infinite range of loading up to capacity as lever is moved from 0 to maximum displacement. Push button control of hydraulic unit. Work table, 60" long. Available attachments include checking rolls, spring loaded centers, adjustable anvils and indicator. To increase production speed, an adjustable stop collar limits the stroke of the ram.

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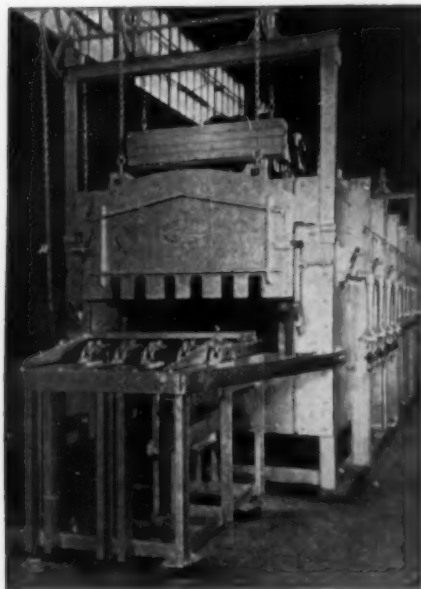
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Bulletin 78

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Helpful electrode color chart is offered by the Arcos Corp. Bulletin 374.

Arc welding inspection chart, designed so that operators can tell at a glance whether welds are being properly made, has been issued by the Lincoln Electric Co. Bulletin 411.

New Phos-Copper booklet explains ways to braze, design and applications. Westinghouse. Bulletin 455.

16-page booklet describes welding and cutting equipment. Victor Equipment Co. Bulletin 489.

Bulletin No. 14, "How To Repair Broken Cutting Tools With Easy-Flo", is filled with practical, instructional copy, profusely illustrated. Handy & Harman. Bulletin 506.

Air Reduction Sales Co. offers 20-page revised price list, "Gas and Electric Welding Supplies and Accessories". Bulletin 512.

32-page booklet presents numerous experience reports from large users of arc welding. General Electric Co. Bulletin 513.

Pocket-sized, slide-type guide showing proper tip sizes, gas pressures, and other data required for machine gas-cutting steel is offered by Air Reduction. Bulletin 527.

TESTING & INSPECTION

Latest technical literature on x-ray and radium protection, together with lead products catalog, has been issued by Bar-Ray Products, Inc. Bulletin 463.

The Bristol-Rockwell dilatometer and its use is described in this leaflet by The Bristol Co. Bulletin 465.

Metallurgical polishing equipment offered by Precision Scientific Corp. is described in illustrated booklet. Bulletin 359.

Various methods and specific applications of the measurement of case depth are described in illustrated pamphlet offered by Allen B. DuMont Laboratories, Inc. Bulletin 339.

Bibliography of more than 700 papers dealing with the polarographic method of metal analysis and a booklet discussing this equipment is offered by E. H. Sargent & Co. Bulletin 338.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 174, 176, 178, 180, 182, 184, 186, 188, 190 and 192.

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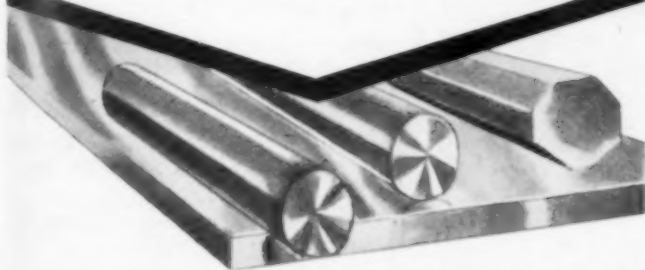
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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

SR-4 strain gage and illustrations of its many uses. Baldwin Southwark. Bulletin 70.

New book contains wealth of practical, usable information on industrial inspection by x-ray. Westinghouse Electric & Mfg. Co. Bulletin 71.

X-Ray Diffraction Unit. General Electric X-ray Corp. Bulletin 72.

Inspection of non-magnetic metals with the new Zyglo method. Magnaflux Corp. Bulletin 78.

Industrial radiography with radium. Canadian Radium & Uranium Corp. Bulletin 79.

Portable Brinell hardness tester and folding Brinell microscope. Andrew King. Bulletin 85.

Universal testing machines and typical uses. Riehle Testing Machine Div., American Machine and Metals, Inc. Bulletin 86.

Optical Aids. Bausch & Lomb Optical Co. Bulletin 94.

Metallographic polishing powder. Conrad Wolff. Bulletin 96.

Metallurgical Equipment. Adolph I. Buehler. Bulletin 97.

"Radiography of Materials" is title of new 96-page book on industrial radiography. Eastman Kodak Co. Bulletin 331.

Stresscoat, a method of analyzing distribution, direction and value of local strains. Magnaflux Corp. Bulletin 301.

Hardness testing equipment. Wilson Mechanical Instrument Co., Inc. Bulletin 98.

Attractive, illustrated booklet describes Clark Instrument's precision hardness tester. Bulletin 318.

High intensity industrial illuminator is illustrated and described in new leaflet by Kelley-Koett Mfg. Co. Bulletin 406.

30th Anniversary Catalog shows the special metallurgical equipment offered by Claud S. Gordon Co. Bulletin 410.

Laboratory and industrial pH meters are described and explained in leaflet issued by Beckman Instruments Division. Bulletin 422.

8-page illustrated leaflet describes line of industrial instruments offered by the Brush Development Co. Bulletin 428.

Use Handy Coupon on Page 164
for Ordering Helpful Literature.

Other Manufacturers' Literature Listed
on Pages 164, 166, 168, 170, 172, 176, 178,
180, 182, 184, 186, 188, 190 and 192.

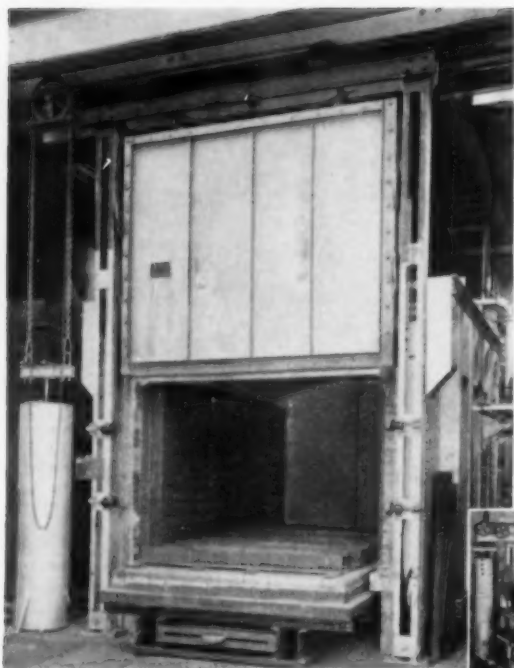
IN THE **WARS PRODUCTION MIRACLES**
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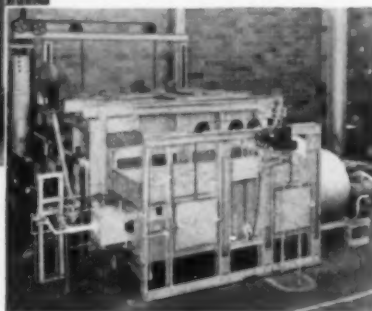
Today, the whole world knows of the thousands of bombers, engines, and millions of vital replacement parts that flow from the Ford Motor Company plants. To manufacturers contemplating the use of Roto-Finish, we thought it might be interesting to learn that this startling new mechanical finishing process has a part in this production miracle. Roto-Finish was used at Ford's for deburring and certain finishing operations on a substantial number of the Pratt and Whitney engine precision parts shown here. And it did the work much faster and more uniformly than hand methods.

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VULCAN designs and installs furnaces for all heating and heat treating operations. Consultation with our engineers will incur no obligation.

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Details and various applications of the portable tensile tester are shown in 8-page leaflet by W. C. Dillon Co., Inc. Bulletin 491.

Advantages and speed of testing with the Magnetic Analysis Corp. Comparator are described and pictured in brochure just released. Bulletin 492.

6-page leaflet describes the constant temperature equipment offered by American Instrument Co. Bulletin 493.

New Carbon and Sulphur Determinator is described in this new 8-page leaflet. Harry W. Dietert Co. Bulletin 501.

Many tips and suggestions for industrial laboratories are presented in 24-page March issue of "Curve and References" by Wilkens-Anderson Co. Bulletin 502.

4-page folder on the inspection and control of surface finish is offered by George Scherr Co. Bulletin 508.

New Norelco electronic Searcher Modal 150 is described and seven features illustrated in this 4-page leaflet. North American Philips Co. Inc. Bulletin 517.

New 50 KV industrial x-ray unit and its features and applications, are presented in this 8-page leaflet. Picker X-Ray Corp. Bulletin 525.

TEMPERATURE CONTROL

Potentiometer temperature indicators. Foxboro Co. Bulletin 82.

Micro-Optical Pyrometers. Pyrometer Instrument Co. Bulletin 89.

Pyrometer control of high speed salt baths is described in new booklet by Brown Instrument Co. Bulletin 324.

Industrial thermocouples. Arkis S. Richards Co. Bulletin 93.

Operating principle and type available of the synchronous-motor driven cam program timer are covered in this new 4-page folder. Automatic Temperature Control Co. Inc. Bulletin 487.

36-page thermocouple data book and catalog describes product prices and presents recommendations for thermocouple users. Wheelco Instruments Co. Bulletin 490.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 180, 182, 184, 186, 188, 190 and 192.

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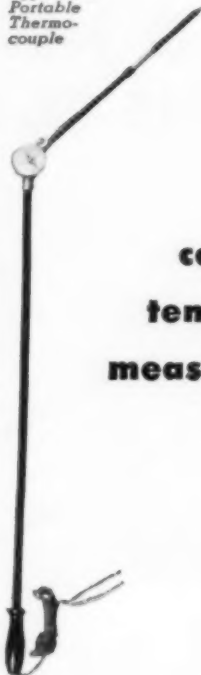
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Portable
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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

The Bristol Co. announces a new bulletin B220 describing its new line of Free-Vane Electronic Controllers for temperature, pressure, liquid level and humidity. Bulletin 503.

48-page revised catalog, "Micrometers and Speedomax Rayotube Pyrometers", pictures applications of the equipment to important new temperature-measuring jobs. Leeds Northrup Co. Bulletin 514.

Many types of pyrometers and temperature controllers are illustrated in this 4-page leaflet by Illinois Testing Laboratories, Inc. Bulletin 514.

HEATING • HEAT TREATMENT

"Isothermal Quench Baths Applied to Commercial Practice" is the title of this 12-page paper, a practical and useful discussion of S curves in heat treatment. Ajax Electric Co. Inc. Bulletin 461.

32-page booklet describes 16 interesting industrial uses of high frequency electrical induction. Ohio Crankshaft Co. Bulletin 459.

Quenching oil coolers in heat treating practices are described in this leaflet by the Sims Co. Bulletin 463.

New catalog No. 406 describes Rockwell valves for control of air, gas and liquids. W. S. Rockwell Co. Bulletin 466.

Neutral baths for heat treatment and details of their use are described in this booklet by the A. F. Holdrege Co. Bulletin 469.

24-page technical data and operating manual covering the Deepfreeze low temperature industrial chilling machines has been issued by Deepfreeze Div., Motor Products Corp. Bulletin 398.

36-page catalog illustrates Kold-Hold line of thermal, sub-zero and stratosphere processing and testing machines. Kold-Hold Mfg. Co. Bulletin 99.

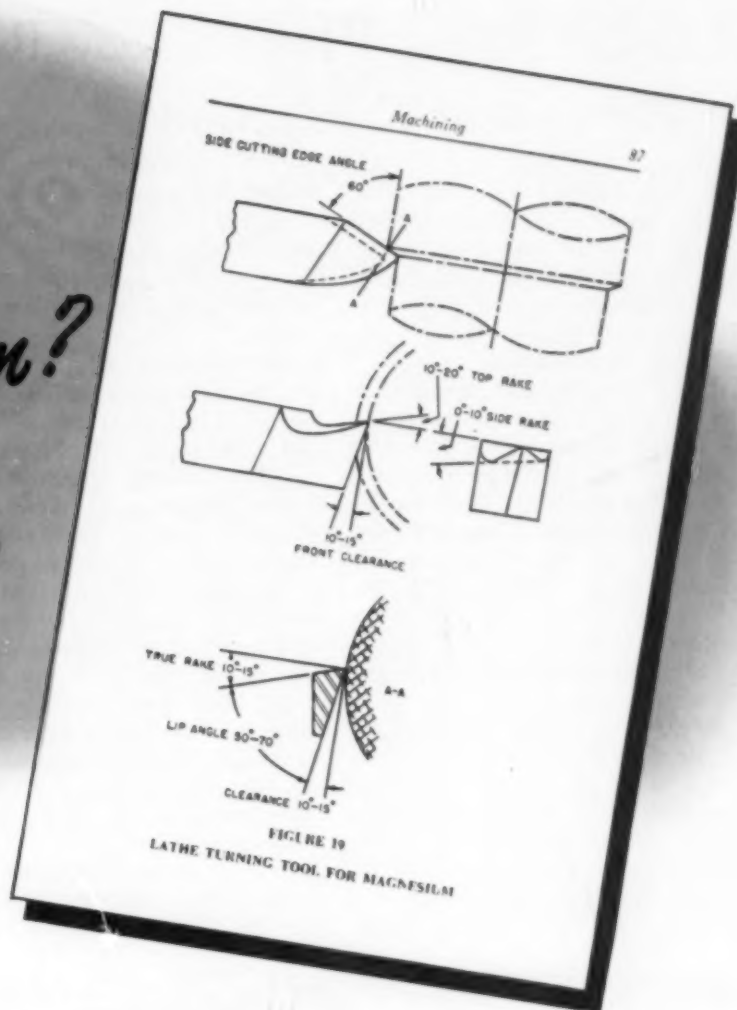
Induction heating. Induction Heating Corp. Bulletin 103.

Internally heated salt bath furnaces and pots. Upton Electric Furnace Div. Bulletin 102.

Use Handy Coupon on Page 164 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 180, 182, 184, 186, 188, 190 and 192.

Machining Magnesium?

Here's how to
assure
maximum
production



Magnesium alloys have excellent machinability. They can be cut at high speeds and feeds, taking a fine finish, while maintaining close tolerances. Tools used with other metals usually perform satisfactorily on magnesium, but best results can be obtained if these rules are followed:

1. Cutting edges must be kept sharp. Tool faces should be polished to insure free cutting action and reduce the tendency for magnesium particles to adhere to the tool tip. Clearances for chips should be large.

2. Magnesium is generally machined dry. In special cases, however, a cutting fluid is used. Do not use oil-water emulsions.

3. Taps and reamers should be slightly oversize, compared to such tools for other metals; magnesium cuts close to size.

4. Because of a lower modulus of elasticity, magnesium parts must be firmly but carefully clamped, to insure accuracy and prevent deformation.

These are just the high spots of "Do's and Don'ts" learned in our more than twenty years of producing magnesium products. For Mazlo Magnesium literature on this subject, write Aluminum Company of America, Sales Agent for Mazlo Magnesium Products, 1706 Gulf Building, Pittsburgh 19, Pennsylvania.

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The war production program called for heat resistant containers and other parts in unprecedented quantities. To meet these requirements for urgently needed chromium-nickel alloy castings, we have greatly increased our Amsco Alloy production.

Amsco Alloy is made in a variety of analyses, to meet the requirements of the entire range of applications which call for maximum resistance to heat and corrosion. Their proper application minimizes replacements and conserves less suitable metals for other uses—therefore, Amsco Alloy has a dual war-time role: serving and saving.

The pictures show a few representative applications:

R-810—One of a great many Amsco Alloy F-1N retorts made for producers of magnesium metal used for incendiary bombs and aircraft parts. Each retort weighs 1,100 lbs. A cap is welded on one end.

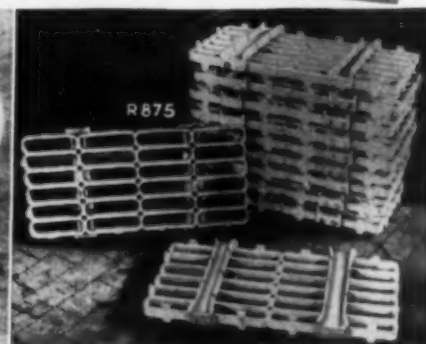
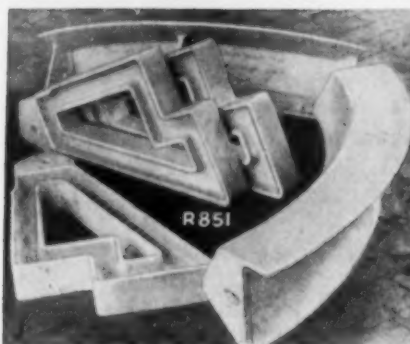
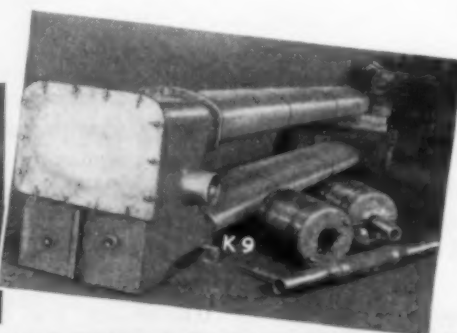
K-9—One of 11 Amsco Alloy F-1 and F-10 assemblies for gas-fired con-

trolled atmosphere muffle type furnaces for heat-treating machine gun clips. Muffles are 20' long, cast in three sections, butt-welded together and bolted to discharge housing by flanges.

R-851—Amsco Alloy F-10 frame castings for rotary type furnace, consisting of guides weighing 71 lbs. each and supports, 53 lbs. each.

R-875—Besides speeding production of needed parts, these Amsco-Johnson reversible tray assemblies (U. S. Patent 2,303,882) conserve metal three ways: (1) Made of Amsco Alloy F-1; (2) Rails cast separately eliminate heating and cooling stresses that result when rails are cast integral because of heavier metal section where rail joins tray; and (3) Rails can be removed by torch-cutting holding pins, permitting trays to be "flopped over" to compensate for warpage.

Ask for Bulletin 1041-A covering Amsco Alloy Heat Treating Containers, Retorts and Furnace Fixtures.



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Chicago Heights, Illinois

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

8-page pictorial bulletin describes the heat treating service of Continental Industrial Engineers, Inc. Bulletin 107.

Electric Furnaces. Ajax Electrothermic Corp. Bulletin 106.

Lithco, the chemically-neutral heat treating process, and Lithcarb, the process for fast, bright gas-carburizing. Lithium Corp. Bulletin 101.

Furnaces for heat treatment of aluminum, magnesium and their alloys. Lindberg Engineering Co. Bulletin 271.

Gas, oil, and electric heat treating and carburizing furnaces. Holcroft & Co. Bulletin 114.

Industrial furnaces, equipment for bright annealing stainless steels and ammonia dissociation equipment. Drever Co. Bulletin 115.

Industrial ovens, rod bakers, welding rod ovens, furnaces. Carl-Mayer Corp. Bulletin 116.

Full muffle and other heat treating furnaces described in catalog by Charles A. Hones, Inc. Bulletin 117.

Non-metallic Electric Heating Elements. Global Div., Carborundum Co. Bulletin 119.

56-page vest pocket data book on heat treating practices and procedures. Chicago Flexible Shaft Co. Bulletin 118.

Molten Salt Baths. E. I. duPont de Nemours & Co., Inc., Electrochemicals Department. Bulletin 123.

Handling cylinder anhydrous ammonia for metal treaters. Armour Ammonia Works. Bulletin 128.

Certain Curtain Furnaces. C. L. Hayes, Inc. Bulletin 134.

Air-Oil Ratiotrol for proportioning flow of fuel oil and air to oil burners. North American Mfg. Co. Bulletin 135.

Two new bulletins on vertical carburizers and on carbonia finish. American Gas Furnace Co. Bulletin 139.

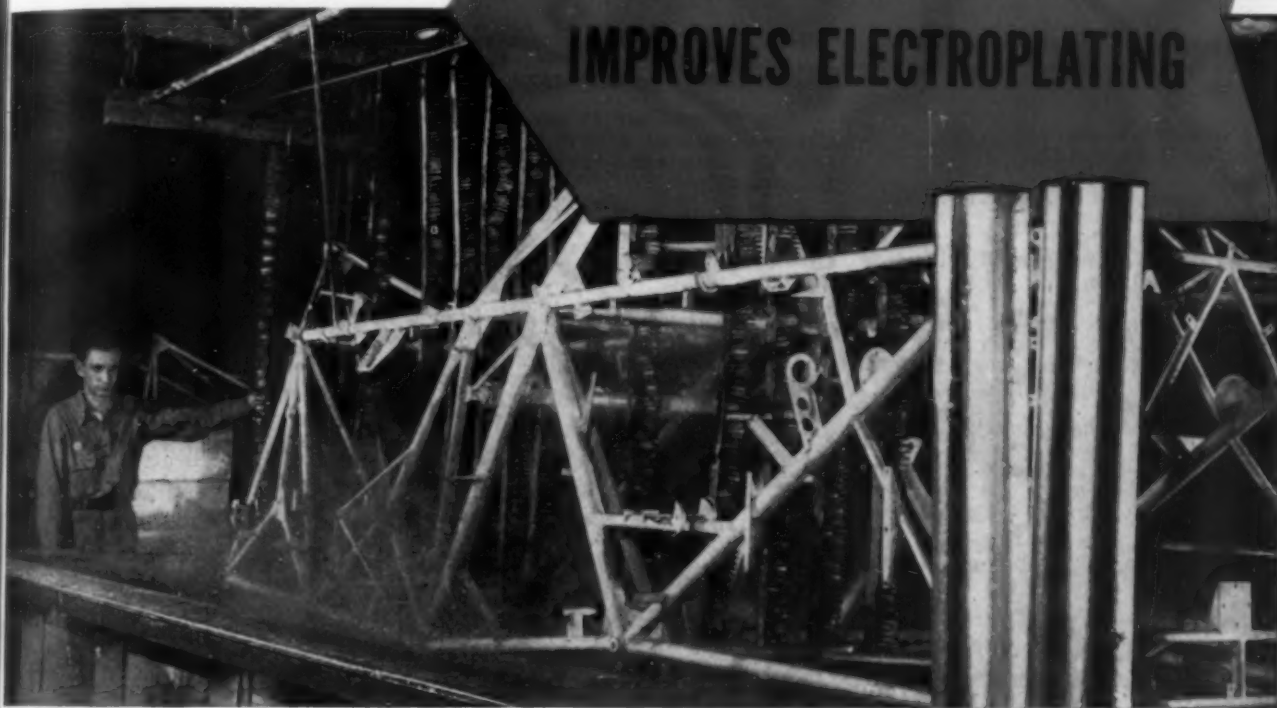
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Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 182, 184, 186, 188, 190 and 192.

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Equally effective in still tank and electro-cleaning

So positive are the advantages of Turco Prosoolv B that prominent electroplaters have switched to this new cleaner immediately following tests *although they had considered satisfactory the materials they had been using.*

Turco Prosoolv B insures the chemical and physical cleanliness that is essential to 100% bonding to steel of zinc, cadmium, chromium and other plate. It removes every trace of oil, grease, smut, paint and rust preventive compound. It contains no soap; leaves no deposit. Rinsing is complete, even though parts may have dried.

A highly concentrated product, Turco Prosoolv B is 100% active. Every particle works; there is no waste.

As this new cleaner is effective in both still tank and electro cleaning, it simplifies stocking and plant procedure where both processes are employed.

Try Turco Prosoolv B for stripping tin deposits formed during the Bullard-Dunn descaling process. A standard

cleaning tank may be used for this. Call the Turco Field Service Man for details on this specially formulated electro and still tank cleaning material which is doing such a notable job the nation over. Write today.

Follow Prosoolv B with Turco Descaler

This second step in preparing steel for plating is as necessary to a perfect job as the primary cleaning operation in Prosoolv B. Any rust, mill, welding or heat-treat scale will prevent bonding of plate. Turco Descaler removes these

without attaching the base metal. Thus the combination of Turco Prosoolv B and Descaler insures quality plating at low cost. Let us furnish full details.

Rust Bar treatment for unplated portions. Partially plated parts, if treated with Turco Rust Bar, are well protected from corrosion during indoor storage although subjected to severe conditions. A thin film of Rust Bar is resistant not only to airborne water vapor, but also to corrosive gases and other types of corrosive agents.



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Write Dept. MP-4

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Controlled atmosphere furnace. Delaware Tool Steel Corp. Bulletin 141.

Dual-Action quenching oil. Gulf Oil Co. Bulletin 132.

Furnaces. Tate-Jones Co. Bulletin 142.

Industrial Carburetors. C. M. Kemp Mfg. Co. Bulletin 143.

Heat treating, brazing and melting of ferrous and non-ferrous metals. Lepel High Frequency Laboratories, Inc. Bulletin 147.

Vertical Furnace. Sentry Co. Bulletin 148.

Conveyor Furnaces. Electric Furnace Co. Bulletin 149.

High and low temperature direct fired furnaces. R-S Products Corp. Bulletin 146.

New Electric Furnace. American Electric Furnace Co. Bulletin 150.

Electric Furnaces for laboratory and production heat treatment. Hoskins Mfg. Co. Bulletin 152.

"The Lectrodryer in the metallurgical industries," a new 4-page bulletin by Pittsburgh Lectrodryer Corp. Bulletin 155.

Pictorial bulletin describes furnaces for heat treating, normalizing, annealing, forging. Vulcan Corp. Bulletin 161.

High Temperature Fans. Michiana Products Corp. Bulletin 158.

Protective combusted atmospheres in Hevi Duty Electric Co. furnaces are discussed in 12-page Bulletin 316.

Flame-type mouth and taper annealing machine for steel cartridge cases. Morrison Engineering Corp. Bulletin 154.

Turbo-Compressor data book shows how to calculate compressed air systems for a dozen different applications. Spencer Turbine Co. Bulletin 329.

No-Carb, a liquid paint for prevention of carburization or decarburization. Park Chemical Co. Bulletin 156.

Catalog of heat treating materials. Heatbath Corp. Bulletin 322.

Standardized sizes of semi-muffle and pot-type furnaces are described and pictured in new leaflet by Dempsey Industrial Furnace Corp. Bulletin 354.

Use of pulverized coal in the metallurgical industries, equipment and designs, are described by Amble Morton Co. in Bulletin 361.

Rapid oil coolers and heat transfer equipment are described in new catalog issued by Bell & Gossett Co. Bulletin 365.

Laboratory and tool room furnaces. Mahr Mfg. Co. in new Bulletin 327.

82-page catalog describes in detail General Electric heat treat furnaces. Bulletin 380.

Illustrated bulletin on stress-relieving, car-type furnaces. Radiant Combustion. Bulletin 375.

Furnaces for heat treating tools, dies and parts are described in new leaflet by Despatch Oven Co. Bulletin 362.

New booklet describes uniform case hardening up to .150" with controlled carburizing baths. American Cyanamid & Chemical Corp. Bulletin 372.

New book "Hardness" describes and evaluates hardness research of noted pioneers, methods of testing and testing instruments. Nitralloy Corp. Bulletin 366.

Four basic heat treating atmospheres are described in new booklet by Westinghouse. Bulletin 353.

"Heat Treating Topics" is title of new bulletin of special interest to heat treaters, issued by Rex & E. Bulletin 424.

Vapocarb-Hump method for heat treatment of steel is the title of newly-revised catalog issued by Leeds & Northrup. Bulletin 453.

The complete line of heat treating furnaces, burners and other equipment of this company is described and illustrated in new bulletin just issued. Eclipse Fuel Engineering Co. Bulletin 483.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 180, 184, 186, 188, 190 and 192.

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WANT TO PREVENT RUST?

Some technical information of great importance
to all interested in anti-corrosion coatings

BACK IN 1932, Quaker made some "rustproofing oils and greases" as did several other concerns in the country. These products were usually mineral products of varied viscosities, some of which contained chromate. They worked pretty well, but just now well no one really knew.

Protecting Aircraft Parts a Serious Problem

Then, one of the large aircraft engine manufacturers got into serious trouble, as precision parts tested on the production line and finished motors shipped to distant points arrived in a deplorable condition due to severe corrosion.

After a preliminary survey by a Quaker Process Engineer, our research laboratory went on the job. The first thing, obviously, was to set up a laboratory method that would accurately and effectively measure the value of a rust preventive coating. Salt sprays had been used in the past but they did not give an accurate measure of what was wanted. Even salt spray tests varied widely.

New Product Developed

So, in 1932 Quaker built one of the first, if not the first, humidity cabinets designed specifically to measure semi-permanent rust preventive coatings of an oil or grease type. For the first time one could accurately compare various "slushing mediums" and measure their value under humid conditions at varying temperatures.

Thus a revolutionary type product was developed and the problem was solved for the aircraft engine manufacturer. A line of Quaker Ferrocotes was born that has a wide acceptance among the aircraft and affiliated industries.

Accurate Measuring Technique

But probably more important, a laboratory technique was developed over the next ten years which has enabled the Quaker organization to develop better and better rust preventives. Today, rust preventives are measured in new type humidity cabinets that maintain a constant flow of moist air at a temperature of 120 deg. Fahr. throughout the cabinet. Thus, test results are reproducible time and time again and are definitely tied in with actual conditions met in the field.

However, preventing rust isn't the only thing that must be measured in a good anti-corrosion coating. Cleanability in solvent or alkali as well as the type of film left on the metal after long standing are of tremendous importance.

"Ideal" Rustproofing

Today, the best type of Quaker Ferrocote gives maximum results when applied at room temperature in a liquid form. The resultant coating is a dry, wax-like film. This does not soak into paper and containers nor run away at high temperatures. It stays where it is put, leaving a rustproofed piece that is really rustproof. It is clean to handle and can be inspected and even "miked" through the film and can be readily removed, if desired.

Quaker Process Engineers are thoroughly trained in the methods and materials necessary to give maximum rustproofing results. Their experience and Quaker Ferrocotes can be admirably applied to precision parts, shells, guns, automotive products or any other metal object.

You may profit considerably by discussing your corrosion problems. There's no obligation. Just write or wire.



QUAKER CHEMICAL PRODUCTS CORP.

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OTHER PLANTS: CHICAGO AND DETROIT—WAREHOUSE STOCKS IN PRINCIPAL INDUSTRIAL CENTERS

WHAT'S NEW

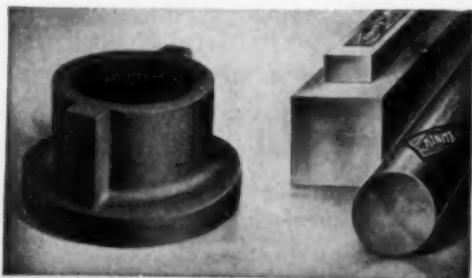
IN MANUFACTURERS' LITERATURE

Thirty-two-page booklet, "Production Data," presents several articles from "The Houghton Line." E. F. Houghton & Co. Bulletin 475.

112 pages packed solid with down-to-earth data on industrial combustion and heat practice. Hauck Mfg. Co. Bulletin 477.

A new technical bulletin gives information on Calliflex Bi-metal. Callite Tungsten Corp. Bulletin 478.

Aero Heat Exchangers for the constant and accurate control of temperature in liquids or gases are described in this 4-page leaflet by Niagara Blower Co. Bulletin 516.



KINITE

THE STEEL WITHOUT AN EQUAL

KINITE is in the high carbon chrome alloy tool steel air hardening class.

An analysis all of its own

Its characteristics:

- 1 Increases production.
- 2 Reduces grinding and retooling time.
- 3 Resists wear and abrasion.
- 4 Excellent machinability.
- 5 Minimum distortion.
- 6 Fine heat treatability.
- 7 Immune to cracking during heat treatment.
- 8 In bar stock or castings.

KINITE alloy air hardening steel offers an unusual combination of features never before found in a steel of this type.

Pamphlets on request.



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Gas-fired tool room furnaces and pot furnaces are described in these two booklets by Bellevue Industrial Furnace Co. Bulletin 522.

Interesting 20-page booklet contains extensive heat treating information, including a glossary of terms, table of weights of square and round bars and a hardness conversion table. Pittsburgh Commercial Heat Treating Co. Bulletin 509.

Heat treatment of steel wire and furnaces used are discussed in this leaflet by Surface Combustion. Bulletin 523.

Merits and economy of pulverized coal firing for metallurgical furnaces are discussed in this bulletin by Babcock & Wilcox Co. Bulletin 530.

REFRACTORIES & INSULATION

Insulating firebrick. Babcock & Wilcox Co. Bulletin 162.

Heavy Duty Refractories. Norton Co. Bulletin 164.

Conductivity and heat transfer charts. Johns-Manville. Bulletin 167.

D-E insulating materials and their application are described in new data booklet by Armstrong Cork Co. Bulletin 208.

Zircon refractories in aluminum open hearth furnaces. Chas. Taylor Sons Co. Bulletin 347.

"Gunmix", a new series of refractories designed for rapid emplacement by air stream and water, is described and illustrated. Basic Refractories, Inc. Bulletin 480.

Steel Plant Cement for hot or cold patching of soaking pits, open hearths, electric furnaces, forging furnaces and reheating furnaces is described in new folder by Electric Refractories & Alloys Corp. Bulletin 407.

"Carbofrax" refractory skid rails are described and blueprinted in many types of furnaces in this 20-page booklet by the Carborundum Co. Bulletin 500.

Wesgo super refractory shapes are described in this bulletin. With ability to withstand almost any amount of thermal abuse, these shapes possess high fusing range (up to 3100 deg. F.), low thermal conductivity and complete freedom from impurities such as iron. Western Gold and Platinum Works. Bulletin 526.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 186, 188, 190 and 192.

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TITUSVILLE has always been a dependable source for quality Forgings. Now, with unexcelled manufacturing facilities, and over fifty years experience in making difficult forgings, TITUSVILLE is,—more than ever before,—your logical headquarters for dependable heavy steel or alloy forgings, always. Our engineering and production skill has been greatly enhanced by wartime "know-how"—in utilizing to best advantage the new alloys, and new precision production methods which make for greater dependability, greater strength and many new uses for forgings.

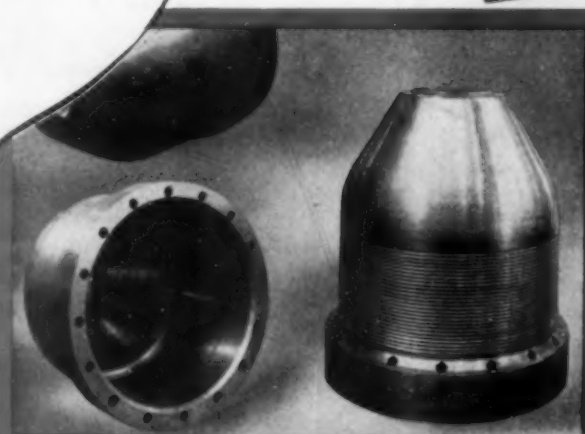


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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

FINISHING • PLATING • CLEANING

Roto-Finish equipment for deburring, buffing, polishing and coloring. Sturgis Products Co. Bulletin 170.

A protective, deep black finish to steel. Heatbath Corp. Bulletin 171.

Alvey Ferguson Co. shows how various product washing problems were solved. Bulletin 172.

Motor-Generators for electroplating and other electrolytic processes. Columbia Electric Mfg. Co. Bulletin 173.

Detrex metal cleaning machines, metal cleaning chemicals and processing equipment. Detrex Corporation. Bulletin 175.

Airless Rotoblast. Pangborn Corp. Bulletin 176.

Rust inhibiting wax coatings for protection of metal. S. C. Johnson & Son, Inc. Bulletin 180.

Cadmium Plating. E. I. duPont deNemours & Co., Inc. Bulletin 177.

Tumbling and cleaning. Globe Stamping and Machine Co. Bulletin 179.

Catalog on finishing and cleaning. Frederick Gumm Chemical Co., Inc. Bulletin 292.

"Indium and Indium Plating". Indium Corp. of America. Bulletin 182.

Jetal process and its characteristics as a protective coating. Alrose Chemical Co. Bulletin 213.

Cyanide zinc and bright zinc plating with Turco Type X, Turco Porekleen and Turco Penetrol is described in this 10-page booklet by Turco Products, Inc. Bulletin 495.

Special data sheets on compounds for various cleaning jobs are offered by MacDermid, Inc. Bulletin 436.

Technical bulletin describes materials developed to meet specialized processing and cleaning needs. Kelite Products, Inc. Bulletin 438.

"Deoxidine" for a better rust removing and metal cleaning job is described along with several applications in this 4-page leaflet. American Chemical Paint Co. Bulletin 528.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 188, 190 and 192.

COLUMBIA MOTOR GENERATORS

for Electroplating and
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Columbia Generators embody every feature essential for dependable, 24-hour operation. They are built for electroplating service in sizes of 6 to 20 volts, 500 to 20,000 amperes, for anodic treatment of aluminum in sizes of 40, 50, and 60 volts, 500 to 3,000 amperes. Columbia Generators for other electrolytic processes range from 1/2 to 250 KW, 100 to 40,000 amperes, 6 to 60 volts.

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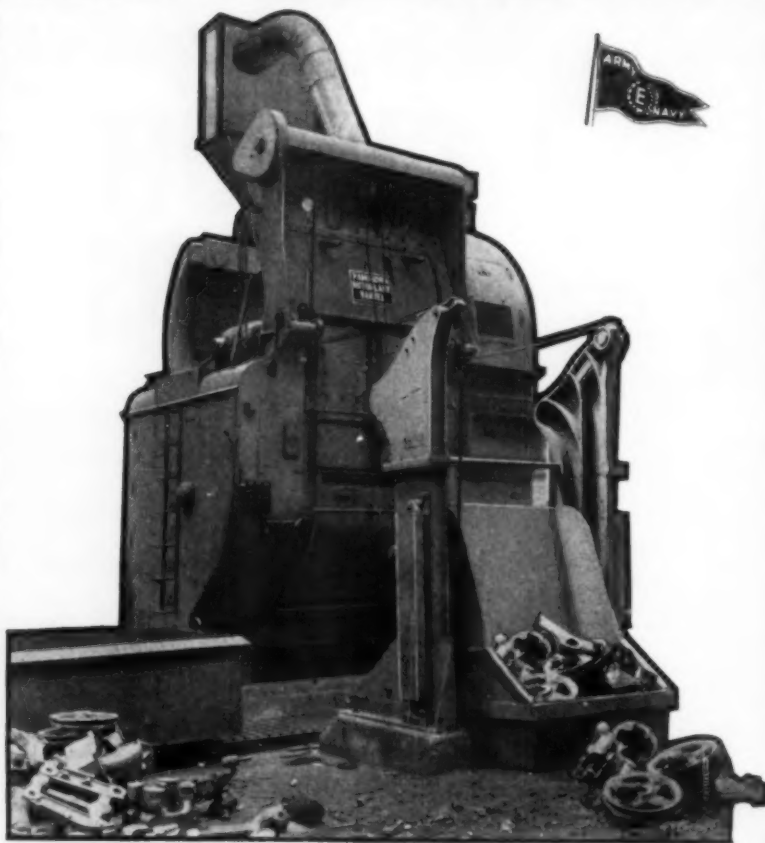
By following this practice, one size of circuit breaker will meet a wide range of current demands, provide maximum flexibility in manufacturing control, and reduce your production cost.

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For **ECONOMY—SPEED—SATISFACTION**—use **ROTOBLAST**.

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Several practical data sheets show cleaning methods used on aluminum, brass and steel. Diversey Corp. Bulletin 446.

"Surface-Peening" by shot-blasting to improve the strength of metal parts is described in this leaflet by W. W. Sly Mfg. Co. Bulletin 521.

ENGINEERING • APPLICATIONS • PARTS

Carburizing Boxes. Pressed Steel Co. Bulletin 193.

Chace manganese alloy No. 772 in sheets, strips, rod and special shapes described by W. M. Chace Co. Bulletin 190.

Heat treating fixtures for pit-type furnaces are shown in new booklet by Driver-Harris Co. Bulletin 363.

Pressed steel pots are described by Bell & Gossett Co. in new Bulletin 364.

New 32-page illustrated booklet contains much data on manganese steel for the railroad industry. American Manganese Steel Div. Bulletin 388.

Illustrated leaflet presents data and uses of special alloys resisting corrosion, high temperatures and abrasion. The Duraloy Co. Bulletin 390.

New information sheets on tapered and formed tubes have just been issued by Summerill Tubing Co. Bulletin 369.

54-page booklet, "File 41—Engineering Data Sheets", gives complete facts on Ampco Metal's physical properties and service record. Bulletin 368.

Many applications and savings through use of drop forgings are shown in Drop Forging Topics issued by Drop Forging Assn. Bulletin 240.

Electrical, corrosion and heat resisting alloys in rod, wire, ribbon and strip forms. Wilbur B. Driver Co. Bulletin 192.

Catalog gives complete specification data on Bunting bearings and bars. Bunting Brass & Bronze Co. Bulletin 343.

Specifications and physical properties of bronze and aluminum alloys are shown in Olds Alloys Co. Bulletin 457.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 190 and 192.



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It's teamwork that's winning victories on every front . . . between workers and soldiers . . . and between materials and machines.

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They are used for propelling carriers through the furnace . . . as in handling flexible trays (also of PYRASTEEL) for heat treating shells . . . also in conveying small munitions parts in carburizing boxes . . . or as right and left hand screws for carrying axles directly on the screw flights.

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The performance of PYRASTEEL at high temperatures insures steady furnace operation at low cost.



PYRASTEEL Flexible Tray Conveyor for conveying aerial bombs through heat treating furnace.

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Reference data book entitled "The Improvement of Metals by Forging" has been issued by Steel Improvement & Forge Co. Bulletin 409.

Interesting and informative literature on "Pomet" powder metallurgy products. Powder Metallurgy Corp. Bulletin 454.

Industrial applications of National and Karbate carbon and graphite products are illustrated in 16-page booklet issued by National Carbon Co., Inc. Bulletin 426.

24-page catalog is guide to properties and use of Monsanto plastics. Monsanto Chemical Co. Bulletin 319.

X-Ray Inspected Castings. Electro Alloys Co. Bulletin 197.

Steel Castings. Chicago Steel Foundry Co. Bulletin 199.

Heat Resisting Alloys. General Alloys Co. Bulletin 200.

Pipes and Tubes. Michigan Steel Casting Co. Bulletin 201.

Cr-Ni-Mo Steels. A Finkl & Sons Co. Bulletin 203.

Industrial baskets, crates, trays and fixtures. Rolock, Inc. Bulletin 204.

Handsome 12-page brochure pictures the cast steel breech rings and their advantages as produced by the Ohio Steel Foundry Co. Bulletin 51.

Many types of heat treating and pickling baskets and containers are shown in new booklet by the Standard Wood Corp. Bulletin 445.

Complete line of Mallory radio electrical and electronic parts, with sizes, dimensions and rated capacities is described in new 36-page booklet. P. R. Mallory & Co., Inc. Bulletin 448.

The Wilco Blue Book deals with the 29 Wilco Thermometals, their properties, functions, applications and temperature ranges. H. A. Wilson Co. Bulletin 531.

Illustrated leaflet describes stainless steel castings by Atlas Foundry Co. Bulletin 437.

Illustrating several heat resistant alloy applications, this 4-page leaflet cites four factors essential to efficient alloy use. Sterling Alloys, Inc. Bulletin 504.

Cooper standard alloys. Cooper Alloy Foundry Co. Bulletin 206.

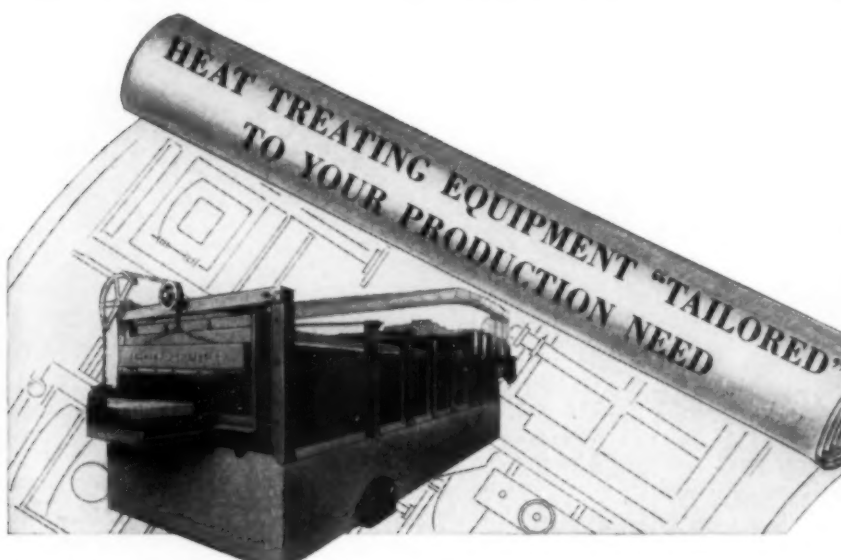
Three-color chart of decimal equivalents. John Hassall, Inc. Bulletin 458.

Drop, hammer and upset forging. Kropp Forge Co. Bulletin 534.

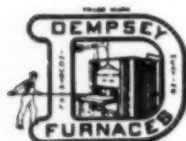
Steel Forgings. Transue and Williams Steel Forging Co. Bulletin 533.

Specifications and diagrams are included in description of welded rings and bands. American Welding & Mfg. Co. Bulletin 536.

Use Handy Coupon on Page 164 for Ordering Helpful Literature. Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188 and 192.



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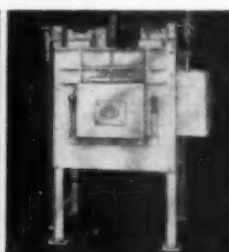
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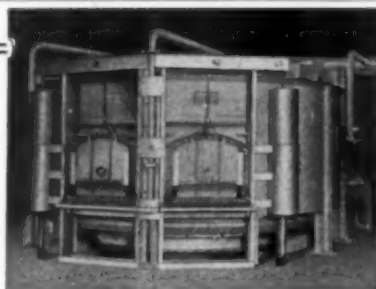
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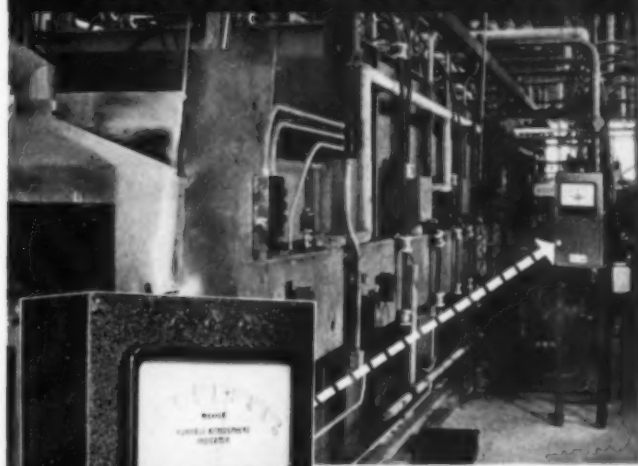
Also manufacturers of Burners, Blowers, Torches, Controllers, Blacksmith Forges.

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Weaver Furnace Atmosphere Indicator used on General Electric Brazing and Hardness Furnace at Burgess-Norton Co., Geneva, Ill.



REDUCE SPOILAGE!
SAVE MAN HOURS!
LOWER COSTS!

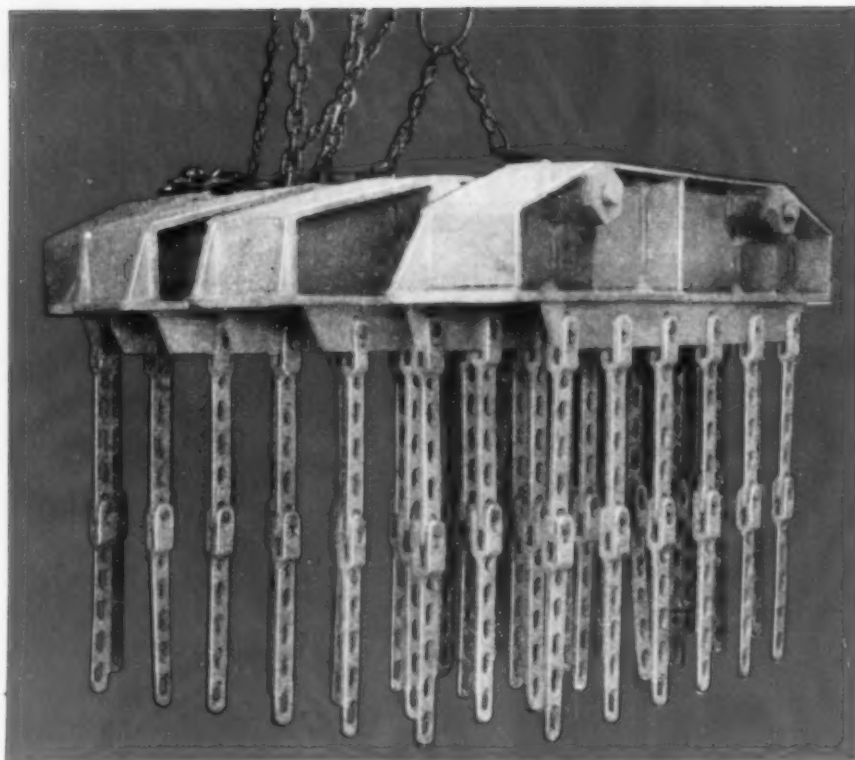
The Weaver Furnace Atmosphere Indicator is to atmosphere as the pyrometer is to temperature. Each makes possible the control of an important variable in heat treating. The Weaver Indicator enables even the inexperienced operator to determine, maintain and reproduce the most ideal atmosphere for any given operation. There's no need to risk losses due to previously unknown causes! Weaver's continuous indicating feature quickly warns of unsuspected changes in furnace atmosphere, gas composition, pressure and air infiltration.

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Heat-Resistant and
Corrosion-Resistant
ALLOY CASTINGS

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

MELTING • CASTING • MILL OPERATIONS

Ingot Production. Gathmann Engineering Co. Bulletin 185.

Crucibles for brass, copper, aluminum and magnesium industries. Electro Refractories and Alloys Corp. Bulletin 183.

This ring-binder presents 24 pages on the use and effect of Titanium in steel and cast irons. Titanium Alloy Mfg. Co. Bulletin 470.

52-page booklet describes Moore rapid Lectromelt furnaces for iron, steel, nickel and copper melting and refining. Pittsburgh Lectromelt Furnace Corp. Bulletin 404.

"Electromet Products and Service". Electro Metallurgical Co. Bulletin 186.

Interesting and helpful information available on the use of alloy pots for heating operation by the Swedish Crucible Steel Co. Bulletin 137.

Operating Features, capacities, charging methods of the Heroult electric furnace. American Bridge Co. Bulletin 215.

Attractive booklet describes growth, facilities and offers valuable alloy hints. Niagara Falls Smelting & Refining Corp. Bulletin 246.

Foundry ovens for core baking, mold drying and pasting are illustrated in new 4-page leaflet by Despatch Oven Co. Bulletin 510.

GENERAL

New leaflet describes interoffice communication system offered by Executone Communication Systems. Bulletin 385.

Use Handy Coupon on Page 164 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188 and 190.